This Month's Cover: Can tester built by Lima-Hamilton Corp. Testing with air, the machine rejects every can that does not hold pressure until it reaches the reject station during its travel around the wheel.

MACHINE DESIGN

Vol. 22—No. 5 May, 1950

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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CONTENTS

Plastics—A Reappraisal (Editorial) 85

Rocket Motor Hydraulics—for controlling explosive propellants 86
By George P. Sutton

Scanning the Field for Ideas 92
Plastic deformation—economical deep drawing—tension control—precision lapping—matching bearings

Why Machine Parts Fail—Part 1—Fracture and Inherent Strength 95
By Charles Lipson

Planetary Gear Train Analysis 101
By Merl D. Creech and George W. Randle

Designing for High Production—and reduction in production costs 103
By John L. Moody

Contemporary Design 106
Console controls sorting—adjusts belt tension—plastics enhance styling—printer operates hydraulically—precision feed

Production Processes—Part 51—Plastics Molding 111
By Roger W. Bolz

History of Machine Hydraulics—Part 6—Pumps, Motors and Valves 124
By H. G. Conway

Hardfacing—in original design for increased life 126
By F. W. Weigel

Charts Simplify Calculations—Part 2 (Production and Design) 129
By Tyler G. Hicks

Employing Computer Components in Machine Control—Part 1 131
By F. W. Cunningham

Standard Tolerances for Molded Plastics (Data Sheet) 135

DEPARTMENTS

Itemized Index 7
Topics 82
Men of Machines 140
New Parts and Materials 142
Engineering Dept. Equipment 154
Helpful Literature 157
Noteworthy Patents 160
Professional Viewpoints 162
News of Manufacturers 164
The Engineer's Library 168
Sales and Service Personnel 180
Sales Notes 188
Meetings and Expositions 194
Design Abstracts 198
New Machines 210

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MATERIALS SPECIFICATION • DESIGN ANALYSIS
MACHINE COMPONENTS • ENGINEERING MANAGEMENT

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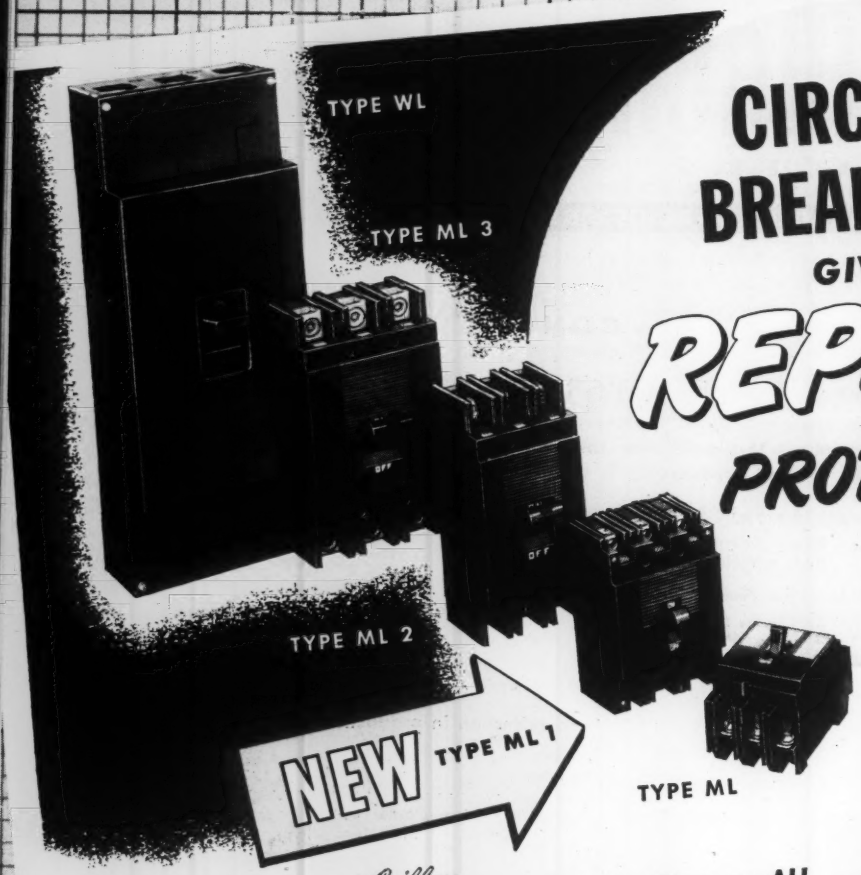

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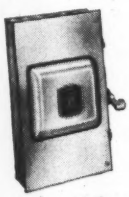
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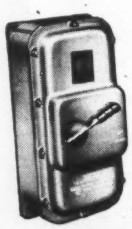
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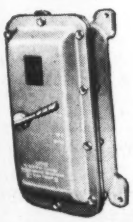
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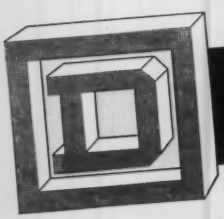

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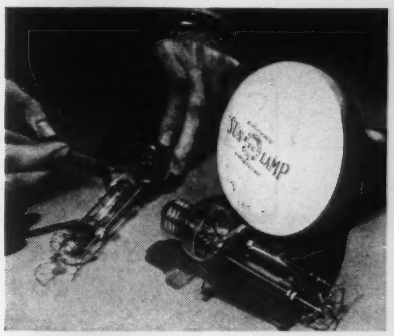
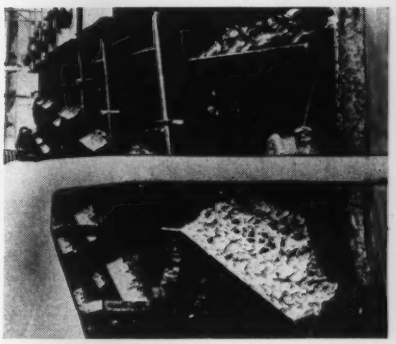
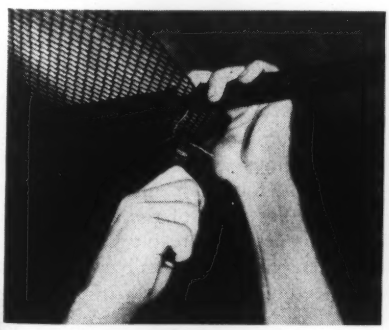


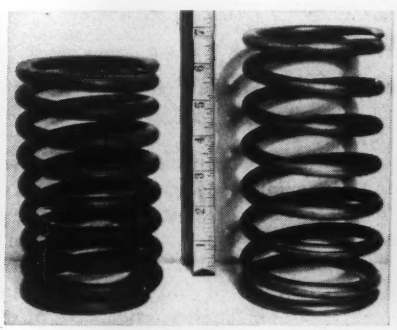
1. *750°F.* is the operating temperature within the Westinghouse Sun Lamp. But Westinghouse has no wire worries. Flexible, 38-strand Nickel wire is used for inside conductors to provide electrical conductivity while resisting heat. The sturdy structural frame supporting the whole assembly is made of "D"® Nickel wire.



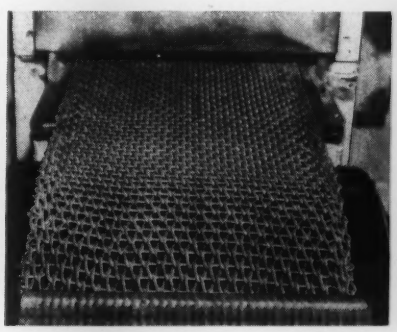
2. ***Corrosion*** quickly would have ruined ordinary metal wire on these salt-water trash screens. But the operator (a leading chemical company) planned for long life—and got it—with Monel. Installed in 1940, not a single Monel screen has yet to be replaced because of corrosion failure.



3. ***Strength*** is only one of the many properties needed in architectural tie-wire. Also needed, is resistance to attack by building dampness, lime, cement, plaster. The metal must be workable, too, so that it can be twisted tight without breaking. *Monel* tie-wire ends the wire worries of many architects. "Double-Looping" is not needed.



4. ***Springs*** of Inconel perform well at elevated temperatures. In the above picture, both springs were originally 7" long. After compression testing at 750°F., the spring at left lost 1" of its original height. The Inconel spring (at right) lost nothing. Remember this when you're choosing springs for "hot spots."



5. ***Resistance to oxidation and heat*** were twin "musts" for the wire used in this conveyor belt to carry parts through a brazing furnace at 1300-2040°F. Made of woven Inconel wire, this belt was in constant use for more than two and a half years; was still serviceable and strong when the furnace was dismantled.

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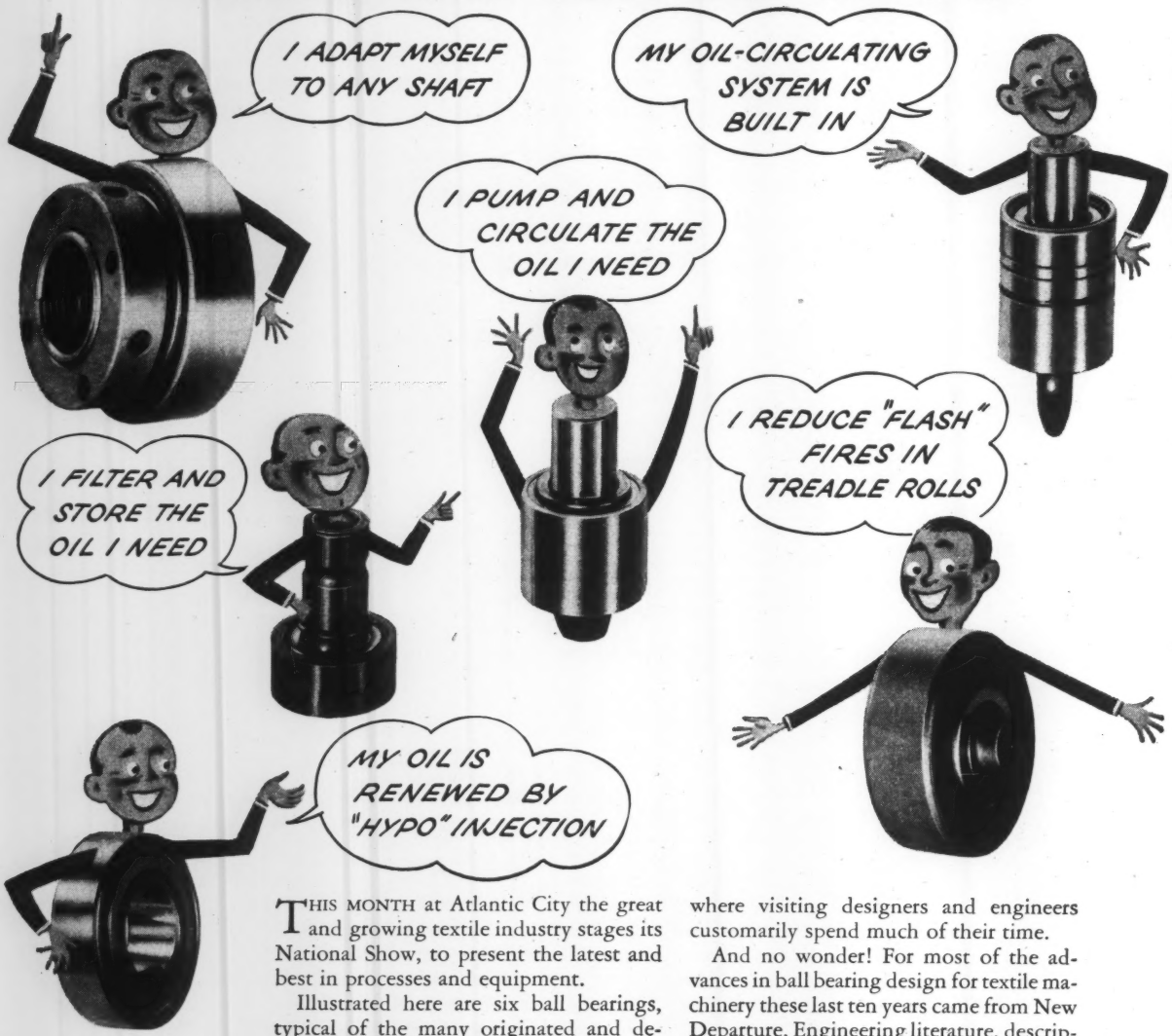
I ADAPT MYSELF TO ANY SHAFT
MY OIL-CIRCULATING SYSTEM IS BUILT IN
I PUMP AND CIRCULATE THE OIL I NEED
I FILTER AND STORE THE OIL I NEED
I REDUCE "FLASH" FIRES IN TREADLE ROLLS
MY OIL IS RENEWED BY "HYPO" INJECTION

THIS MONTH at Atlantic City the great and growing textile industry stages its National Show, to present the latest and best in processes and equipment.

Illustrated here are six ball bearings, typical of the many originated and developed by New Departure. They will be on display at the New Departure exhibit where visiting designers and engineers customarily spend much of their time.

And no wonder! For most of the advances in ball bearing design for textile machinery these last ten years came from New Departure. Engineering literature, descriptive of them, will be mailed promptly to requests on business letterheads.

Nothing Rolls Like a Ball... **NEW DEPARTURE BALL BEARINGS** 93

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

ITEMIZED INDEX

Classified for convenience when studying specific design problems

Design—General

Belt tension control, Edit. 106
Deep drawing, Edit. 92
Feeding mechanism, Edit. 109
Fracture analysis of machine parts, Edit. 95
Hardfacing, Edit. 126
Hydraulics, rocket motor, Edit. 86
Machine control by computer components, Edit. 131
Molded plastics, standard tolerances (Data Sheet), Edit. 135
Monel deformation studied by polarized light, Edit. 92
Planetary gear train analysis, Edit. 101
Plastics molding, Edit. 111
Punching power and drawing forces, charts, Edit. 129
Redesign of calculator for high production, Edit. 103
Sorting control, remote, Edit. 107
Tension control torque device, Edit. 92

Engineering Department

Equipment:
- Drafting room, Edit. 154
- Experimental, Edit. 154, 162; Adv. 244

Supplies:
- Drafting room, Edit. 154; Adv. 168, 195, 214, 218, 238, 245

Finishes

Enamel, Edit. 152

Materials

Aluminum alloys, Adv. 37-43
Brass, Adv. 83
Carbon-graphite, Adv. 26
Ceramics, Edit. 198
Copper alloys, Adv. 29, 83
Felt, Adv. 201
Gray iron, Adv. 20
Nickel alloys, Adv. 5
Plastics, Edit. 111, 135, 145; Adv. 19
Rubber and synthetics, Adv. 11, 155, 234
Stainless steel, Adv. 45, 74, 84
Steel, Edit. 146; Adv. 24, 52, 167
Zinc alloys, Adv. 223

Parts

Balls, Adv. 242
Bearings:
- Ball, Edit. 144; Adv. 6, 13, 156, 240
- Needle, Adv. 188, 202
- Roller, Adv. 13, 61, 156, 161, 225
- Sleeve, Adv. 73, 149, 193, 219, 240

Belts, Edit. 106, 152; Adv. 209, 234, 249
Brakes, Adv. 50, 204
Brushes, power, Adv. 166
Cams, Adv. 245
Carbon-graphite parts, Adv. 26
Castings:
- Centrifugal, Adv. 198
- Investment, Adv. 178, 250
- Permanent mold, Adv. 43
- Sand, Adv. 43, 187

Chains:
- Conveyor, Adv. 79
- Roller, Adv. 49, 59, 78, 191, 231

Clutches, Adv. 165, 204, 241, 252
Collars, Adv. 237
Controls (see Electric, etc.)
Counters, Edit. 145; Adv. 257
Couplings, Edit. 143, 146
Diaphragms, Adv. 21
Drives, adjustable speed, Edit. 150; Adv. 62
Electric accessories, Edit. 142, 144, 145; Adv. 246
Electric controls:
- Actuators, Edit. 152; Adv. 241
- Alternators, Edit. 143
- Circuit breakers, Adv. 4, back cover
- Computer components, Edit. 131
- Contactors, Adv. 174
- Control assemblies, Adv. back cover
- Electronic, Edit. 145, 147
- Relays, Edit. 143; Adv. 190
- Starters, Adv. 67, 80
- Switches, Edit. 147, 148, 150, 152; Adv. 176, 237
- Thermostats, Adv. 28
- Timers, Adv. 212
- Transformers, Adv. 63, 251
- Voltage regulators, Edit. 143

Electric generators, Adv. 255
Electric heating units, Adv. 221
Electric motors:
- Fractional hp, Edit. 144, 150; Adv. 1, 17, 32, 46, 55, 72, 171, 197, 205, 234, 240, 249
- Integral hp, Edit. 148; Adv. 17, 46, 51, 56, 77, 197, 234, inside back cover
- Gearmotors, Edit. 142; Adv. 58, 63, 229, 255
- Timing, Adv. 22
- Synchro, Adv. 233

Engines, Adv. 200, 210, 236, 238
Extrusions, Adv. 38
Fasteners:
- Locking, Adv. 75, 206, 216
- Nuts, bolts, screws, Adv. 10, 12, 16, 164, 173, 196, 237, 246, 253

Filters, Edit. 143; Adv. 215, 247
Fittings, Adv. 235
Floor plates, Adv. 180, 194
Forgings, Adv. 8, 41, 246
Gages, pressure, etc. (see also Instruments), Adv. 65
Gears, Edit. 101, 162; Adv. 8, 23, 48, 206, 236, 245, 249
Generators, (see Electric generators)
Ground parts, Adv. 167
Heat exchangers, Adv. 220
Hose (see Tubing)
Hydraulic equipment:
- Controls, Adv. 213
- Cylinders, Edit. 148; Adv. 175, 182, 185, 207, 226
- Pumps, Edit. 146; Adv. 14, 53, 211, 213
- Systems, Edit. 86; Adv. 9, 44, 211, 213
- Valves, Edit. 86, 147; Adv. 15, 182, 251

Instruments, Edit. 145; Adv. 63
Joints, Edit. 147; Adv. 250
Lubrication and equipment, Edit. 147; Adv. 69, 151, 186, 201, 258
Machined parts, Adv. 245
Mechanical controls, Edit. 142, 160
Motors (see Electric motors)
Mountings, rubber, Adv. 192
Pins, dowel, Adv. 238, 250
Plastic parts, Edit. 111
Pneumatic equipment:
- Cylinders, Adv. 175
- Motors, Adv. 242
- Compressors, Adv. 250
- Vacuum pump, Adv. 250
- Valves, Edit. 143, 150; Adv. 183, 242

Powder-metal parts, Adv. 214, 219
Pulleys and sheaves, Adv. 253
Pumps (see also Hydraulic and Pneumatic), Edit. 144, 162; Adv. 31, 224, 246, 252
Reducers, speed, Edit. 142; Adv. 208, 222, 229
Rings, retaining, Adv. 217
Roll assemblies, Adv. 198
Rubber and synthetic parts, Adv. 11, 155
Screw machine parts, Edit. 103; Adv. 40
Seals, packings, gaskets, Edit. 146, 152; Adv. 2, 21, 30, 60, 153, 159, 169, 179, 236 249, 251
Shafts flexible, Adv. 216
Sheaves, Edit. 148; Adv. inside front cover, 181
Spindles, Adv. 47
Springs, Adv. 170, 199, 218
Sprockets, Adv. 59
Stampings, Edit. 103; Adv. 244
Torque converters, Adv. 241
Transmissions, variable speed, Edit. 144
Tubing:
- Finned, Adv. 66
- Flexible, metallic, Adv. 64, 230, 252
- Flexible, nonmetallic, Edit. 146
- Nonmetallic, nonflexible, Adv. 203
- Seamless, Adv. 76, 163, 177, 227, 232
- Welded, Edit. 148; Adv. 70, 177, 232

Universal joints, Adv. 244
Valves, (see also Hydraulic and Pneumatic), Adv. 54, 235, 247
Vibrators, Adv. 244
Weldments, Adv. 212
Wheels and casters, Adv. 210, 245
Wire and wire products, Edit. 142; Adv. 5, 172

Production

Gear shaping, Adv. 48
Hardfacing, Edit. 126
Machines, special, Adv. 34; 247
Powder metallurgy, Adv. 184
Welding equipment, Adv. 189, 228

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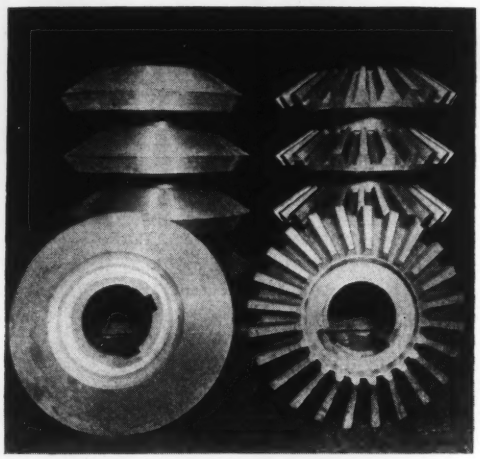

Most users of Bethlehem gear blanks swear by them and couldn't be won over to any other kind. We aren't talking to those users here. Our purpose is to reach the man who needs gear blanks but hasn't yet tried the Bethlehem product.

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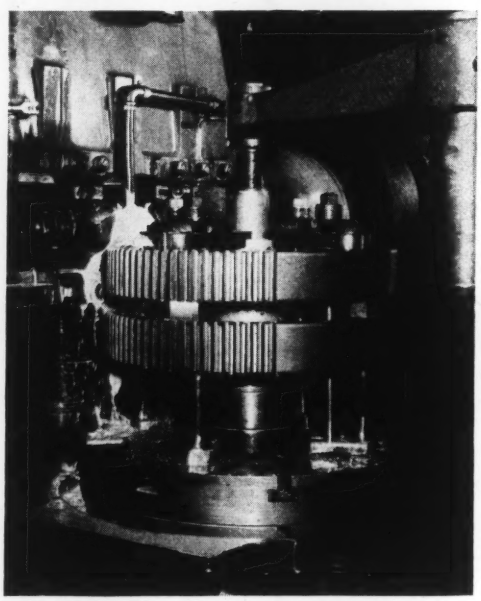

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- **Provides Straight-through Wiring**—Three line leads at top; three load leads at bottom.
- **Provides Positive and Precise Overload Protection**—Snap action bi-metal DISC instead of "solder pots" or bi-metal strips.
- **Permits Front-removal of ALL Parts**—No special tools required.
- **Corrosion-resistant Parts All Plated**—Enclosure Bonderized.
- **Meets NEMA Standard Mountings.**
- **Gives Quietest Operation**—Self-aligning magnet construction.

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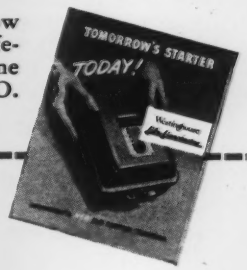

TOPICS

GRAPHITE BRUSHES or contacts used in motors and generators on high-altitude aircraft may have their useful service life increased by new lubrication methods devised by Robert H. Savage of General Electric. Formerly accepted as a good lubricant in itself, graphite actually requires a thin film of water or certain organic vapor for its lubrication. For equipment operating at high altitudes where little water vapor is present, brushes are being shielded and water vapor supplied in the space around them. By this method, service of 2000 to 8000 hours has been obtained with brushes that wore out in an hour without water vapor.

AUTOMATIC PLOTTING of x versus y is performed by a new Leeds & Northrup instrument. Two variables to be recorded are converted to d-c signals which control pen travel (x) and chart paper drive (y), both in plus or minus directions. Hysteresis loops, stress-strain curves and other two-variable plottings are claimed to be adaptable to the recorder.

ELECTRICAL GAGE measures thickness of nonmagnetic coating over magnetic steel base. It utilizes the principle that flux reluctance is essentially proportional to gap distance, in this case the coating thickness. Two scales cover the range from 0.0001 to 0.1-inch.

SILICONE RUBBER in an extruded section is used as a seal on the bomb bay doors of the Convair B-36 bomber. According to Stalwart Rubber Co., silicone rubber has been selected because it remains flexible at low temperatures and resists abrasion.

FORGED ALUMINUM BEARINGS for aircraft engines have been developed by Alcoa. On the basis of laboratory tests it is claimed that these bearings will meet rigid performance specifications.

RADIOACTIVE TRACING techniques are being used at MIT to study friction and lubrication phenomena. Investigations under the direction of Dr. J. T. Burwell Jr. have shown that radioactive particles are rubbed off the piston rings in a gasoline engine and welded to the cylinder walls. A Geiger-Muller counter shows the amount of transferred metal; photographic film wrapped around the cylinder gives a more accurate measurement.

MAGNETIZING OF STAINLESS STEEL alloys that are normally nonmagnetic can be accomplished by cold rolling, according to International Nickel Co.

CASTING PRECISION on the order of 0.002 to 0.003-inch per inch is claimed for a new foundry method known as the Croning Process. Molds for the new process consist simply of thin sand shells firmly bonded with Bakelite resins. Short baking and curing periods and relatively small volumes of sand are required.

GILDING METAL is being used to enclose lead bullets used by target shooters on the rifle range. According to Bridgeport Brass Co., these jacketed bullets are manufactured within a weight tolerance of 0.0002-grain. Approaching copper in workability but slightly harder, gilding metal contains 95 per cent copper, 5 per cent zinc.

SILVER PLATED BRONZE RETAINERS are used in bearings that support the main turbine shaft of jet type engines. The silver, 99.99 fine and 0.001 inch thick, reduces the hazard of seizure under the extremes of speed and temperature encountered in jet plane operation. SKF Industries also reports that tin 0.00003-inch thick is plated on bearing races and rollers of piston type engines to prevent water from rusting the polished precision parts.

ULTRASONIC WAVES and a small scale model have been utilized by the Armour Research Foundation to predict the acoustical properties of a proposed structure. In a one-twentieth actual size prototype of a music pavilion, special loudspeakers sent out waves at twenty times the frequency of orchestra music to ultrasonic-sensitive microphones. Dr. H. C. Hardy of the Foundation contends that this method takes the guesswork out of acoustics.

Sight-Light FLOOR LAMP *Sub-Assemblies*

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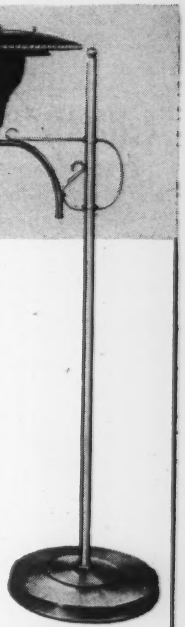

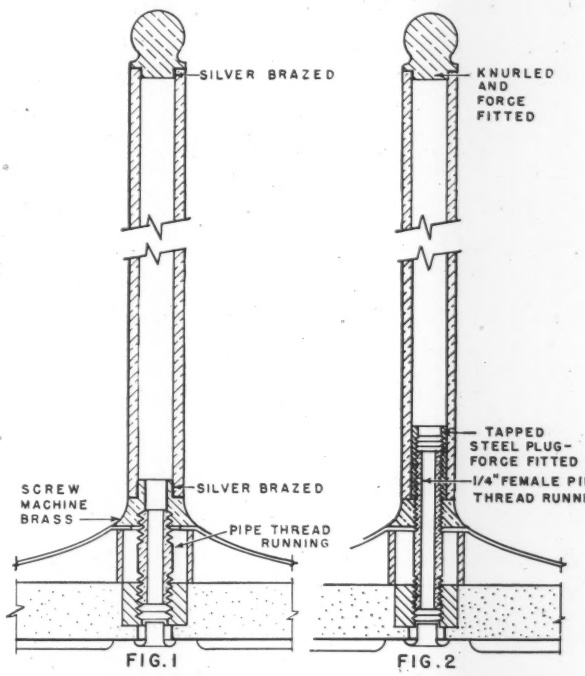

HERE'S HOW IT WAS DONE

Fig. 1 shows the two spots that formerly were silver brazed, and the screw machine brass piece that joined the stem with the base. Fig. 2 shows how top knob and machined brass section that joins the stem with the base are force fitted, eliminating 2 brazing and finishing operations, thus strengthening the lamp and making possible faster assembly and disassembly. Fig. 3 shows base construction simplified even further . . . single screw machine part in the base does the work of three separate parts.

Lamp stem is Revere ¾" O.D. x .680"—.6835" I.D. 70-30 brass tube hard drawn. Support bracket is ⅛" x 1¼" Revere Brass Strip while the outside floor base spun shell is made from 12" wide x .0253 Revere Brass. Screw machine parts at top and base of lamp are Revere 240 type screw machine rod.

Joint efforts of Revere and Plainville Metal Works resulted in elimination of 2 silver brazing and finishing operations . . . faster assembly.

IN working with manufacturers on their various problems, Revere not only takes into consideration how its products can be used to help solve these problems, it also delves into the production methods employed. As a result there have been many cases where Revere and the manufacturer have collaborated to work out new production methods that have not only produced a better product but have also cut production costs.

Newest example of this is the manner in which Revere collaborated with the Plainville Metal Works, Plainville, Conn., in developing the Sight-Light patented reading lamp which they manufacture for the Sight-Light Corp., Deep River, Conn. Originally the knob at the top of the lamp stem was silver-brazed in. Revere suggested this could be a force fit.

Formerly, there had been a screw-machine brass trim section at the base of the lamp stem which had a shoulder on it that was also silver-brazed into the tube. A ¼" running pipe thread nipple with an unthreaded section anchored this screw machine part to the weighted base which was covered by a spun brass disc.

The engineers at the Plainville Metal Works tried various ideas to improve this construction. The final result was a machined section of solid brass that is joined to the lamp stem with a force fit, while the opposite end of this section is threaded for fastening to the base.

Results: 1. Elimination of two silver brazes. **2.** Elimination of two finishing operations, one of which was acid cleaning, and the other, the removal by hand of the discoloration caused by the acid cleaning. **3.** Subassemblies turned out 3 times as fast through a new, faster assembly method that permits finishing before assembly on a mass production basis instead of by hand. **4.** A substantially stronger lamp. **5.** A trim, one-piece screw-machine part at the base that is turned out faster and in a single machine set-up.

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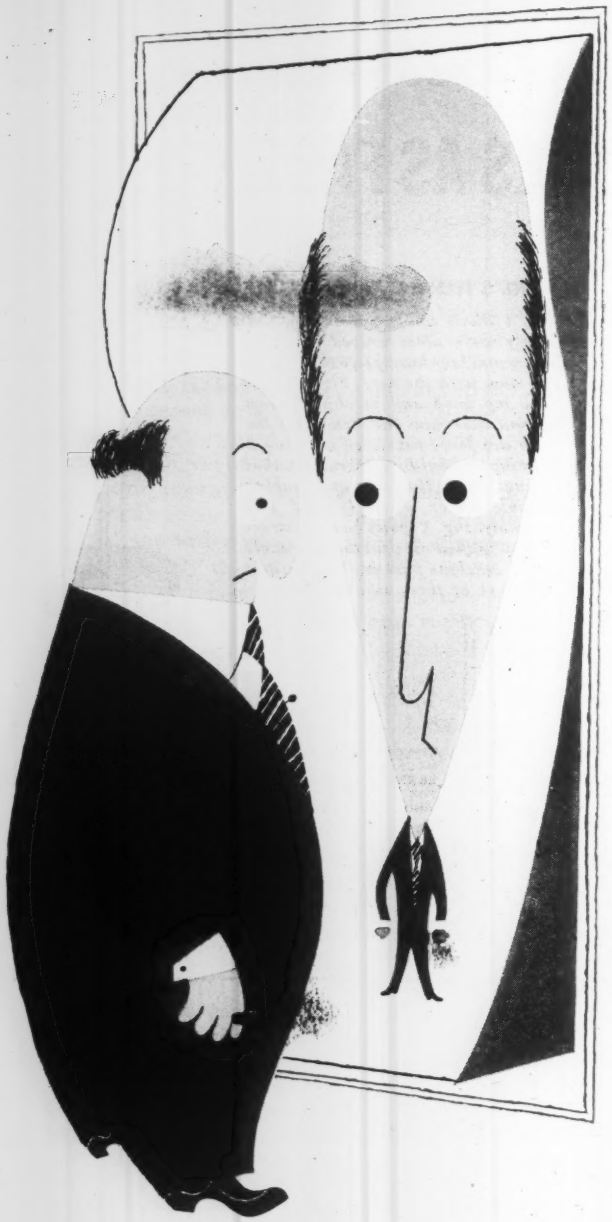

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MAY, 1950

MACHINE DESIGN
A PENTON PUBLICATION

Plastics—A Reappraisal

IT IS perhaps a healthy sign that the glamor which once surrounded the word "plastics" is diminishing. Although younger stars like "electronics," by capturing the popular imagination, have been partly responsible, a more significant factor is that plastics have reached a definite stage of maturity. Their advantages, and their limitations too, are more fully understood so that their proper place in the engineering picture is becoming better recognized.

In numerous rather obvious types of appliances, plastics are competitive with other materials and fabrication methods for components such as housings and handles. Again, electrical and corrosion-resistant properties have long dictated the use of plastics in appropriate applications. However, their greatest appeal to machine designers in general lies in certain unique properties whereby they and they alone can meet special conditions most effectively. Now many mechanical parts such as bearings, gears, and linkages are of molded plastics, with greatly improved performance.

The plastics field is still growing rapidly and new materials with unique properties which completely reverse old concepts about plastics in general continue to appear. In basic engineering properties the different varieties of synthetic resin and filler combinations no more resemble one another than do the different varieties of metals from babbitt to tool steel.

These factors and many others emerge from the extensive article on designing molded and laminated plastics parts which appears elsewhere in this issue. It is abundantly evident that the possibilities of plastics applications in machines have not been adequately explored. Whether this be owing to lack of engineering information, to prejudice as the result of sad experience with misapplications, or to lack of appreciation of the infinite variety of properties now available, it is hoped that the article will stimulate and assist engineers by showing them how to design and apply plastics with assurance of practical success.

Colin Carmichael

EDITOR

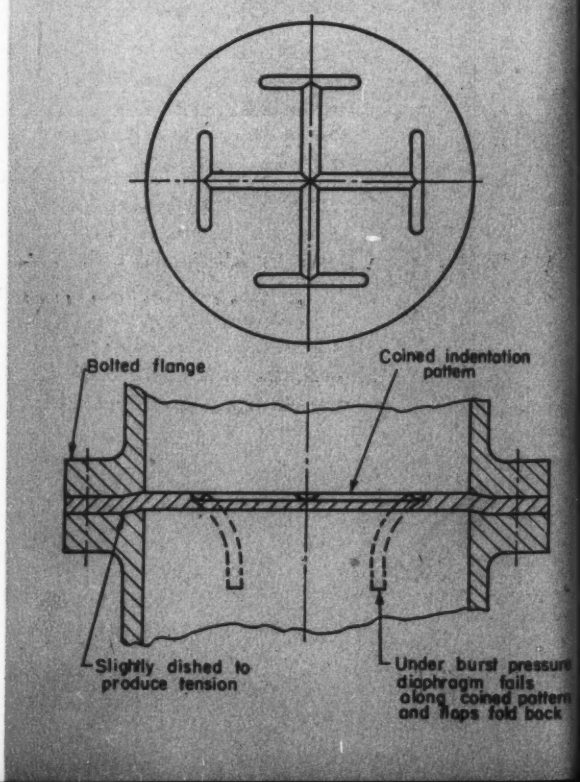
Rocket Motor Hydraulics

Unusual and interesting design problems are encountered in handling and controlling explosive propellants

By George P. Sutton
Supervisor, Propulsion Development
North American Aviation Inc.
Los Angeles, Calif.

HYDRAULIC principles of rocket motor systems are essentially those applicable to other conventional hydraulic equipment. The nature of the highly combustible liquids used, however, and special problems inherent with rocket motors such as heat, corrosion, safety, etc., are vastly different from those of most hydraulic systems and therefore the engineering of the hydraulic circuits employed is somewhat unique.

The feed system used in liquid-propellant rockets is a self-contained, open hydraulic circuit through which the liquid chemical propellants are supplied at a predetermined rate and feed pressure to the rocket motor. These chemicals react to form hot exhaust gases which in turn are ejected at high velocity through a supersonic nozzle, thus developing thrust in the motor by virtue of the reaction principle. General aspects of rocket theory and rocket motors, as well as descriptions of feed systems, have been presented in various references such as those listed at the end of this article.


Bolted flange
Coined indentation pattern
Slightly dished to produce tension
Under burst pressure diaphragm fails along coined pattern and flaps fold back

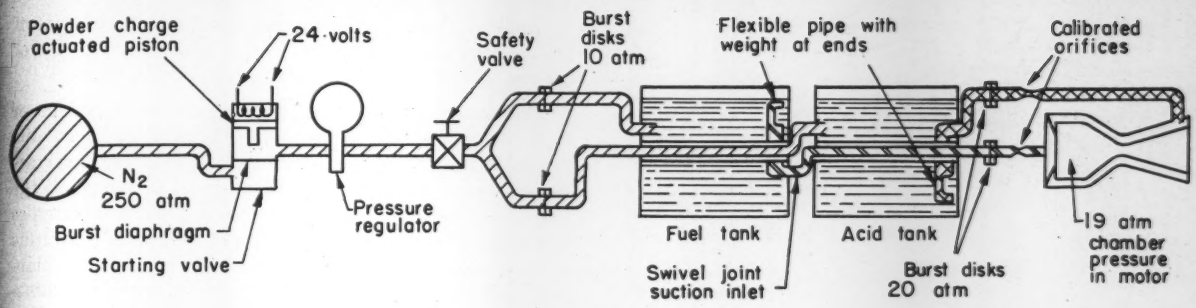


Fig. 1—Left—The NATIV missile on the erection trailer with the launching platform tower in the background

Fig. 2—Left Below—Because of their simplicity, low cost and extremely light weight, this type of burst diaphragm is often used on expendable missiles in place of hydraulic valves

Fig. 3—Above—In hydraulic system of "Wasserfall" antiaircraft missile, compressed nitrogen displaces propellants from tanks into motor. Fuel is isobutyl-ether with concentrated nitric acid as oxidizer. Propellant control is achieved through pressure regulator, relief valve, and four burst diaphragm disks. (Reprinted from Reference 1 by permission)

DESIGN REQUIREMENTS: Influencing the design of hydraulic systems for rocket engines are a number of important factors which will be dealt with individually in the following discussion to bring out the numerous design problems involved.

Application: The exact application of each particular rocket power plant determines several basic features of the hydraulic system. For example, in single-shot, expendable units such as rocket projectiles, *Fig.* 1, emphasis is placed on a simple and cheap hydraulic system using "burst" diaphragms in many places instead of valves, *Fig.* 2. On the other hand, for units that are used repeatedly the emphasis is placed on extreme reliability and additional features for easy inspection and servicing such as fill and drain valves, miscellaneous pressure gages, and provisions for testing valves prior to firing. A typical example of the simple system is the "Wasserfall" antiaircraft rocket engine, illustrated diagrammatically in *Fig.* 3, which has only two valves. The more complicated types, such as the German V-2, may have some forty separate valves and controls.

Small Safety Factors Used

Weight Limitations: Because every pound of system weight saved will permit an increase in flight performance of the overall unit, weight considerations are of prime importance. This is particularly true in high performance units such as are used on guided missiles or rocket airplanes, but it is less important in droppable assisted take-off units. All components, therefore, must have very small design safety factors. Aluminum and magnesium construction is common. Often the turbines driving the feed system pumps are aluminum (including the turbine wheel and buckets), even though this makes necessary the lowering of the gas temperature and the turbine efficiency; but the overall system of gas generator, gas flow control, chemical propellants for making the gas, and the turbine can then be made lighter. Also, pressure drop in lines and valves is often held to a practical minimum because any additional pressure requires a stronger, more powerful and, consequently, heavier feed system. Burst diaphragms are often used not only because they are the simplest type of one-shot operation valve, but also because they can be made leakproof and relatively light.

Metering: Three reasons make accurate metering of the propellants necessary:

1. The two liquids (one a fuel such as gasoline or alcohol, the other an oxidizing agent such as liquid oxygen or concentrated hydrogen peroxide) must reach the motor in the correct proportion to give the desired chemical reaction
2. The combined fuel and oxidizer flow rates must correspond to a predetermined value to give the desired thrust in the rocket motor
3. Any deviation from the design mixture ratio, i.e., the ratio of oxidizer flow rate to fuel flow rate, will leave a substantial residue of one or the other liquid in the airborne supply tanks, thus preventing full utilization of all the available chemicals and reducing the flight performance by unnecessarily increasing the dead weight of the system.

This accuracy of the flow metering governs the basic design of the hydraulic circuit of rocket engines.

Starting: The initial quantities of propellant reaching the rocket motor during the start of operation must be carefully sequenced and metered in order to achieve smooth combustion initiation. Many control valves therefore require special provisions, such as a controlled rate of opening or a low-flow bypass, to assure the proper starting flows. The liquid oxygen valves, *Fig.* 4, of the German V-2, for ex-

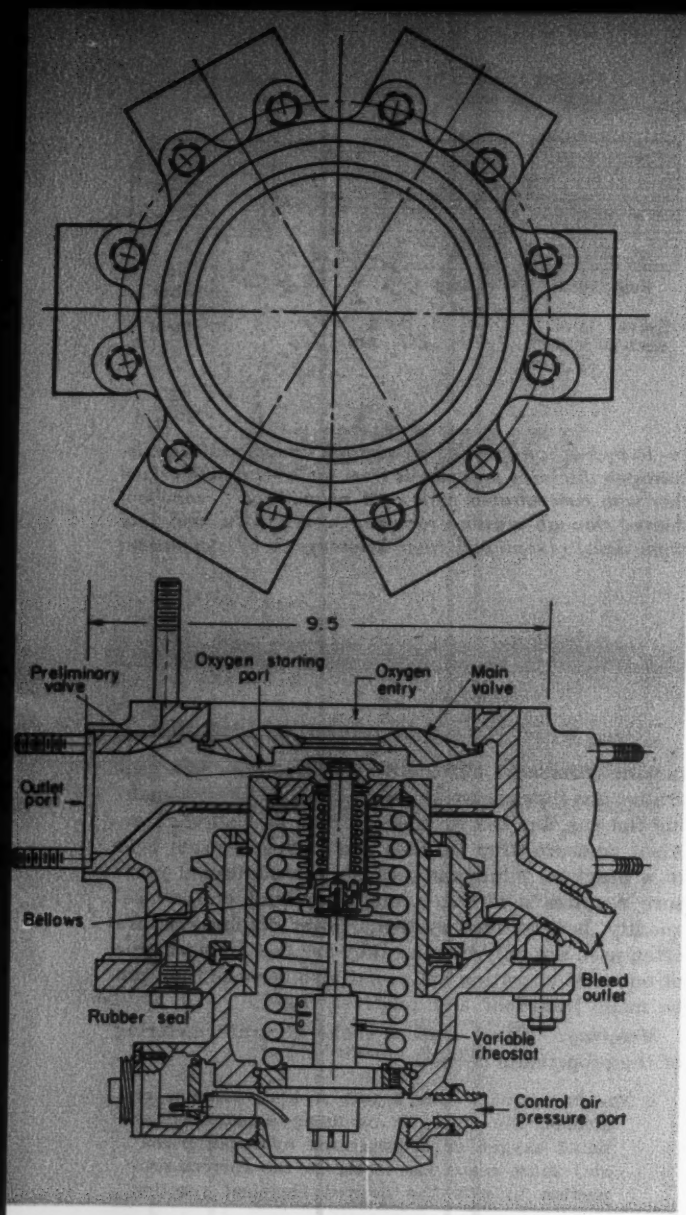


Fig. 4—Oxygen valve of V-2 missile consists of preliminary valve within main valve. Release of control air pressure permits preliminary spring to stretch bellows and lift valve plate off its seat. Oxygen then passes through small ports at reduced flow for starting. The main valve plate is normally held shut, pressure from pumps opening the valve. Position of valve is indicated through variable rheostat. Oxygen is kept out of the control air compartment by double-lip rubber seal

ample, has a built-in by-pass, and the propellant valve shown in *Fig.* 5 has a controlled opening rate. Liquid propellants are always potential explosives and a safe, reliable starting control is necessary. Because rocket motors operate only for short durations (say 5 seconds to 3 minutes) it is essential they be brought quickly to full operating condition. Thus many of the controls and valves must perform their function in a few milliseconds.

General Design: The usual design requirements of reliability, simplicity, economy of fabrication, etc., of course apply also to rocket hydraulic circuits.

TYPICAL SYSTEMS: As with many applications of hydraulic systems, there is a large variety of different circuits, valve combinations, and general arrangements. Rather than to attempt to cover all the many permutations, only the two most common types together with their basic components and hydraulic characteristics will be discussed. These are the pump-feed system and the pressurized gas-feed system illustrated in *Figs.* 6 and 7.

In the pressurized gas-feed system the liquid propellants are displaced from high-pressure tanks by a gas, while the pump system feeds propellants from a low-pressure tank by pumps to the motor; a special power source such as an engine or a turbine is needed to drive the pumps. The choice between the two systems is made for each particular application on the basis of minimum weight for a given thrust and duration. The pressurized system generally is favored for low thrust, short duration units such as those employed for rocket-assisted airplane take-offs, while the turbo pump feed system is more suitable for the long duration and high thrust required for long-distance missiles.

Hydraulic Power Needed is High

Combustion chamber pressures required by rocket motors usually are between 200 and 500 psi and the hydraulic system and its components have to be designed for high pressures of 250 to 700 psi. Because the specific propellant consumption of a rocket is higher than the specific fuel consumption of other known engines, the flow rates and, therefore, the hydraulic power required, are also high. The German V-2 engine, for example, had a flow of 960 gpm of liquid oxygen and 1070 gpm of alcohol; it produced 56,000 pounds of thrust for 65 seconds and required 450 hp to drive its pumps.

CONTROL OF PROPELLANT FLOW: Accurate predetermination of flow usually is achieved by carefully calibrating the hydraulic system and by adjusting the flow to the desired value with a fixed but interchangeable calibrated orifice, which in turn affects the line loss. Accuracies within one per cent are common, and accurate calibration methods are, therefore, necessary. Many calibrations are made with water and corrected for the difference in liquid densities. The design of the injection orifices and the lines have to be such that an approximate calibration is automatically achieved. The calibrated orifices are used merely to obtain a fine adjustment between the hydraulic differences in supposedly identical systems.

Since the injection orifices usually determine flow, they must be made with accurate entrance conditions. Injection hole tolerances of ± 0.0005-inch are often found on drawings, and severe tolerances are placed on properly rounding or chamfering the entrance to these holes. If the injection pressure drop or the hole size is small (say less than 1/32-inch diameter or less than 30 psi), it becomes difficult to obtain identical hydraulic characteristics in a set of injection

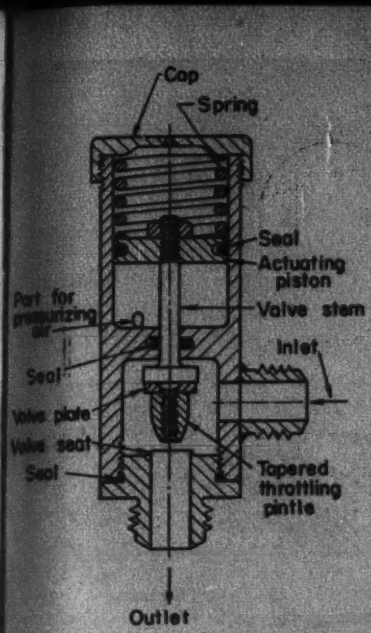


Fig. 5—By controlling the rate of opening of this valve the tapered pintle exposes a gradually increasing port area, thus permitting required increase of flow during starting. (Reprinted from Reference 1 by permission)

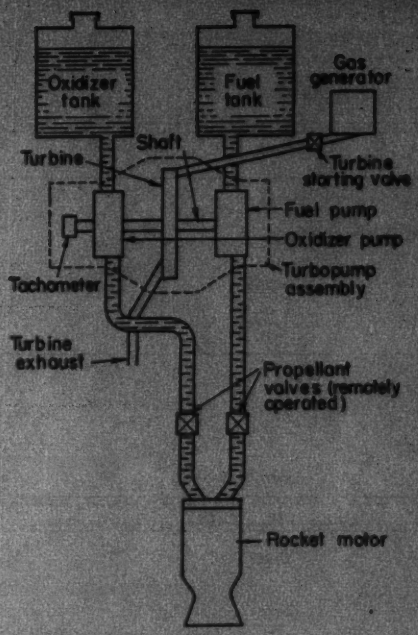


Fig. 6—Schematic of pump feed system in which pumps are driven by turbine which derives power from expansion of hot gases produced in separate generator. (Reprinted from Reference 1 by permission)

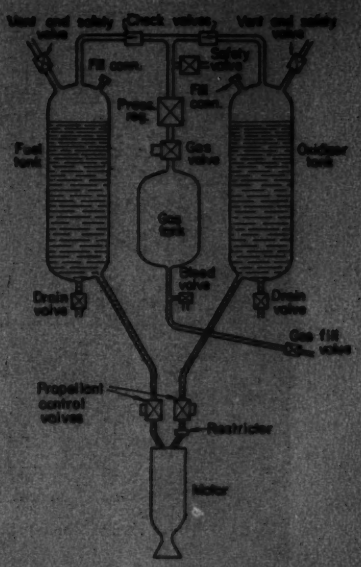


Fig. 7—Pressurized gas feed system usually used for short duration, low-thrust units. Propellants are forced from tanks to the rocket motor by high-pressure gas. (Reprinted from Reference 1 by permission)

holes because variations in discharge coefficient affect the flow more in the low pressure drop ranges and the hole diameter tolerances are a larger portion of the diameter. A typical injector is shown in cross section in the drawing, *Fig.* 8, of a rocket motor.

As mentioned already in connection with the hydraulic requirements of rocket systems, two basic quantities are to be controlled: (1) The ratio of the oxidizer flow to the fuel flow (called mixture ratio) and (2) the total flow (sum of fuel and oxidizer flow). While the mixture ratio control has almost always been achieved by the use of calibrated orifices, several means of controlling the total flow have been successful. One of these is the simultaneous throttling of the liquid propellants in both lines by means of valves similar to the one shown in *Fig.* 5. This method is used in variable-thrust units and to achieve a controlled reduced propellant flow during starting. Another method of changing total flow values has been the changing of the regulated air pressure (change of regulator setting) in pressurized feed systems or the change of pump speed in pump feed systems; the latter usually is accomplished by varying the power supplied to the pumps. A typical valve for throttling propellant is shown in *Fig.* 9.

Flow control by automatic valves, as achieved in many automatic machine tools, has not been applied to rockets as yet because the automatic flow valves usually require high pressure drops, and these cause additional weight. Furthermore, the required large flows present special design problems for these valves.

ROCKET MOTOR HEATING: Design of the rocket motor affects the variation of hydraulic characteristics. The coolant (usually the fuel) is circulated in a cooling jacket around the rocket motor prior to its injection into the chamber. In *Fig.* 8 is shown a typical arrangement with a helical cooling passage around the combustion chamber and nozzle. Cooling of the rocket motor is responsible for the following hydraulic effects:

1. Absorption of heat from the rocket chamber walls raises the temperature of the coolant and changes its density and, therefore, its hydraulic characteristics slightly. The temperature rise depends on the motor design and the physical properties of the coolant
2. Thermal expansion of the chamber walls causes a small change in the dimensions of the coolant passage and thus a change of the effective hydraulic radius
3. High operating pressures cause a small distortion of the motor and the cooling passage, again changing its effective hydraulic radius. The detail design features of the motor and the passage determine the amount of distortion and hydraulic change.

Because of these effects the pressure drop through the cooling jacket is different for the operating condition and the calibration condition (no fire in rocket motor). Empirical correction factors usually are worked out to permit a calibration flow determination and the selection of a suitable calibrating orifice, without actual running of each rocket power plant.

ACCELERATION EFFECTS: The severe accelerations

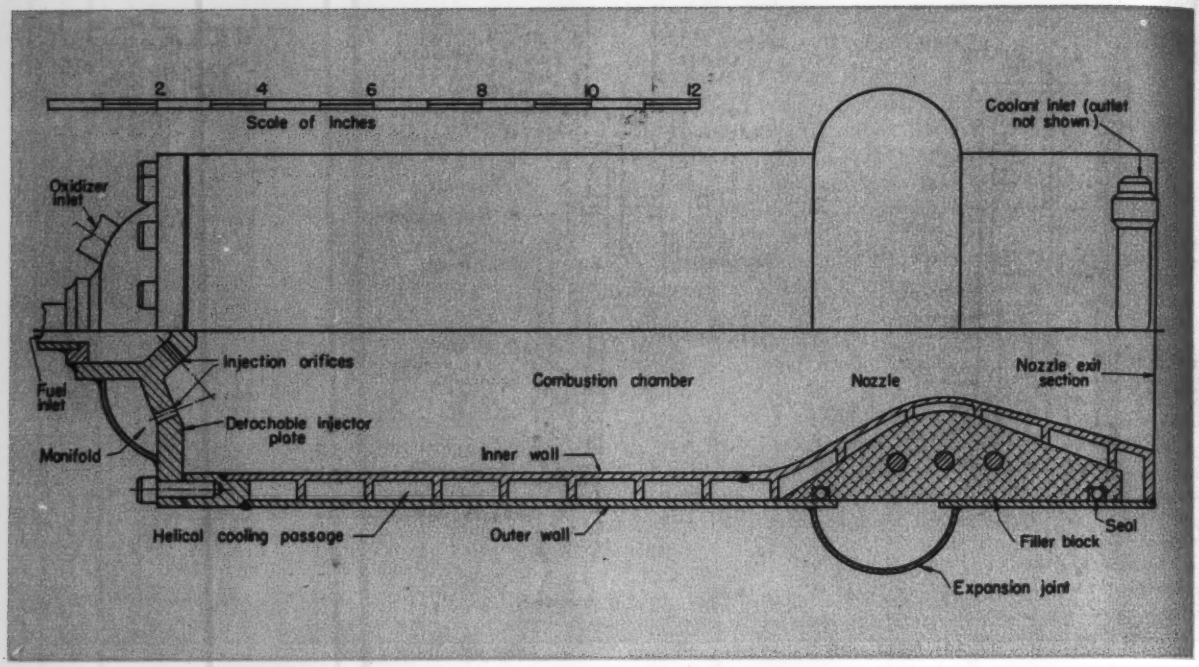


Fig. 8—Typical rocket motor having injector plate, at left, and helical cooling passage around combustion chamber. Fuel usually is utilized as coolant. Change in temperature of coolant through heat absorption changes hydraulic characteristics to some extent

to which a flying supersonic airplane or missile may be subjected create hydraulic heads of considerable magnitude in the hydraulic system. Accelerations of the order of 3 to 7 g may be encountered in most rocket planes and missiles, and up to 10 or 30 g in special antiaircraft missiles and rocket projectiles. With accelerations above 5 g these hydraulic effects cannot be neglected. The problem is complicated by the fact that the vector direction of the acceleration is usually not constant, but varies considerably over the trajectory.

When a hydraulic system is subjected to these accelerations, the head produced by the acceleration of the column of liquid is superimposed upon the head normally produced by the system. For example, if a hydraulic rocket system with a nitric acid oxidizer column of 15 ft (distance betwen injector and surface level in tank) is subjected to 10 g acceleration in the direction of the column, then the pressure at the injector will increase by approximately 100 psi, causing a drastic change in the acid flow.

The pressure increase due to acceleration at the injector is a function of the liquid density. With two dissimilar propellants, say a light fuel and a dense oxidizer, the pressure increase will be different for each fluid and the mixture ratio usually will be disturbed. Thus the design must provide for compensation of the uneven pressure increase. This is frequently accomplished by placing the tank with the lighter propellant further forward in the missile or the airplane, so that the product of density and column length is approximately the same for both propellants. As a design expedient this minimizes the mixture ratio variation, but does not control variation in total propellant flow or thrust.

The accelerations furthermore put severe requirements on feed system components. Valves, for example, must operate satisfactorily under various conditions of forward, backward and side accelerations. Special centrifugal test equipment is required to test valves under simulated acceleration conditions. As a further example, large light-weight propellant tanks, may require considerable stiffening to withstand side accelerations.

PROPELLANT CONSIDERATIONS: Last, but by no means least, are the problems associated with the physical and chemical nature of the propellants. All oxidizers and many of the fuels present hazards in handling and storage. Unfortunately there is no nice propellant. Nitric acid, nitrogen dioxide or hydrogen peroxide are corrosive; liquid oxygen, gasoline or alcohol present a fire hazard; fluorine, hydrazine, or aniline are toxic; hydrogen peroxide or nitromethane can explode spontaneously, and dangerous thermal stresses are introduced by liquid oxygen. A discussion of propellant hazards and properties can be found in Reference 1.

The importance to the hydraulic system is twofold: The system and all its components have to be designed of materials which can withstand the corrosive action and not deteriorate when in contact with the liquids, and special safety provisions have to be included in the system design to cope with the various hazards. For example, the valve shown in *Fig.* 4 has a special natural rubber lip seal to withstand the contraction and hardening action of cold liquid oxygen. The valve in *Fig.* 9 is constructed of stainless steel and aluminum to withstand the cor-

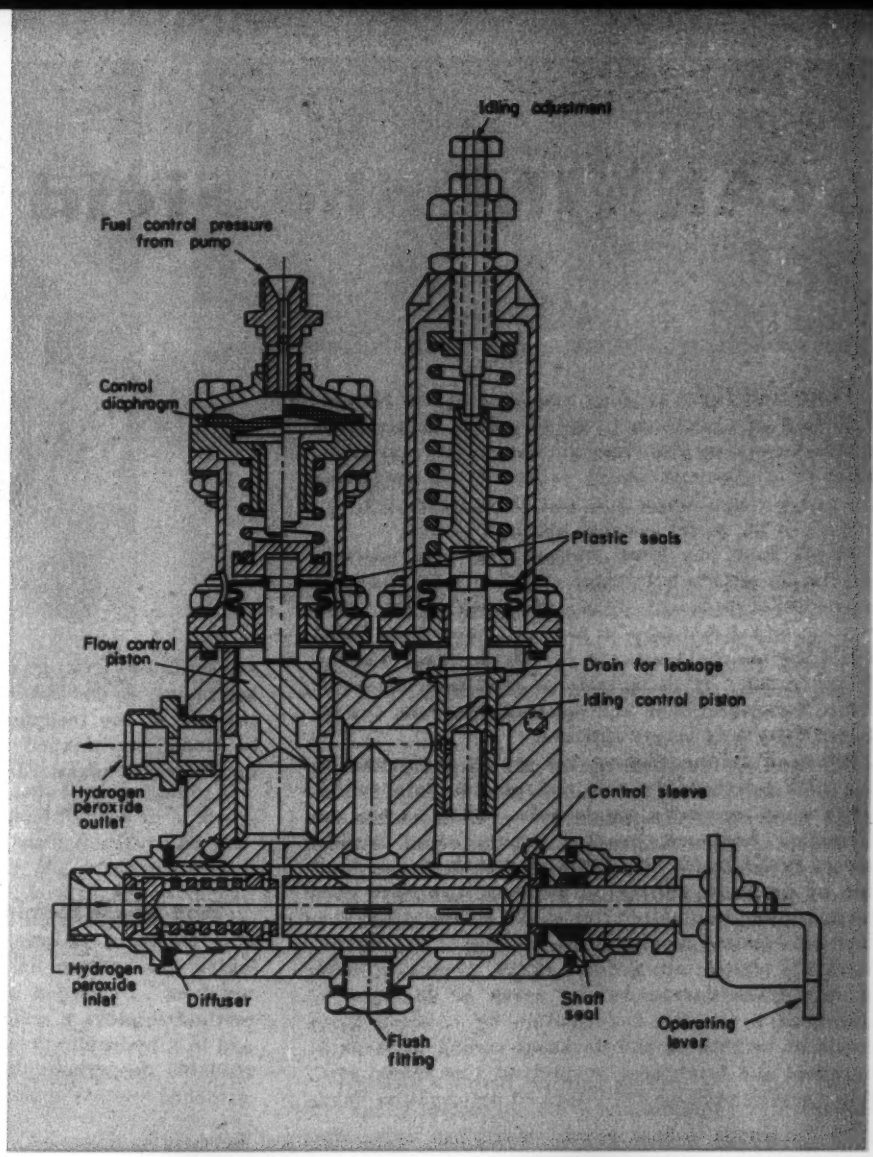


Fig. 9—Peroxide flow control valve as used on Me163 airplane to regulate flow of hydrogen peroxide to a decomposition chamber in which the propellant was catalytically decomposed to gaseous oxygen and water vapor to produce gas mixture for powering turbine. Valve automatically controlled peroxide flow from 100 per cent to 15 per cent and had built-in idling control for supplying approximately two per cent of maximum flow at all times

rosive action of concentrated hydrogen peroxide. The bellows and gasket of this unit are made of special peroxide-resistant plastic and the valve must be assembled without oil or other organic lubricant. The valve also has a drain to dispose of leakage passing around the control pistons.

Selection of materials becomes a separate problem with each corrosive propellant, particularly with seals, gaskets, O-rings, valve seats, packings, and wearing surfaces. Already the discovery and testing of suitable materials has consumed a considerable amount of effort, yet no material has been found to be satisfactory when in contact with nitric acid or hydrogen peroxide for long periods of time, say six months.

Typical examples of special safety provisions are the inclusion of dump valves to dump all the hazardous propellant in case of misfire on a test stand or a launching platform, the use of pump seal drains to take dangerous liquids out of the engine compartment, and a gas flush circuit to permit purging of propellant remains. The valve shown in *Fig.* 9, for example, has a special drain line to dispose of hazardous hydrogen peroxide leakage by dumping it overboard, and a flush fitting to permit washing and flushing of the valve without disassembly. Several safety provisions also are incorporated in the pressurized gas-feed system shown in *Fig.* 7, these comprising the check valves which prevent mixing of propellants when the unit is not in a vertical position, the vent and safety valves, drain valves and fill connections which also can be used for flushing dangerous residue out of the tanks, the bleed valve which is used to dispose of high pressure gases (1500 to 4000 psi) in case of malfunction of any part of the system, and the special regulated-pressure safety valve in the gas line.

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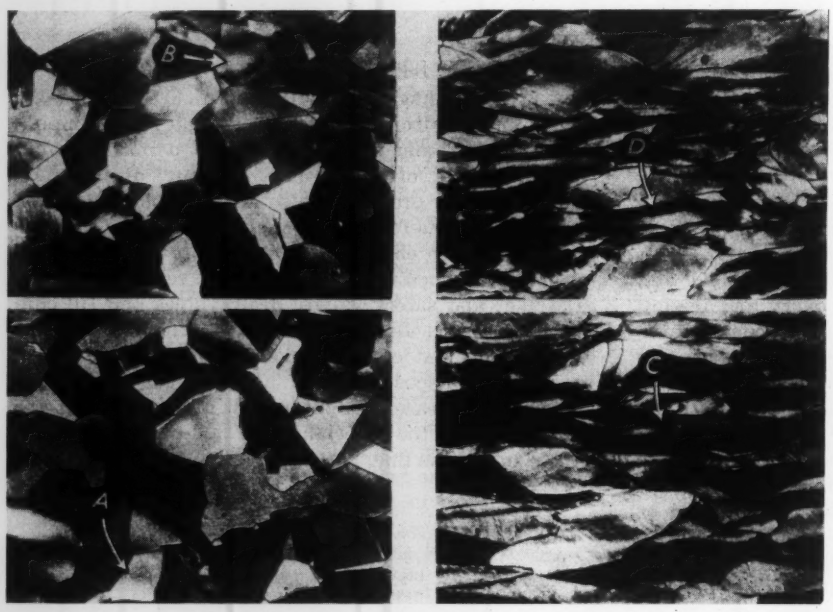
SCANNING the Field For Ideas

Polarized light is being employed at the National Bureau of Standards to study plastic deformation in Monel metal by observing differences in grain orientation in stressed specimens, below. When specimens are given a light etch with Monel contrast etch, the surface of the metal becomes optically active.

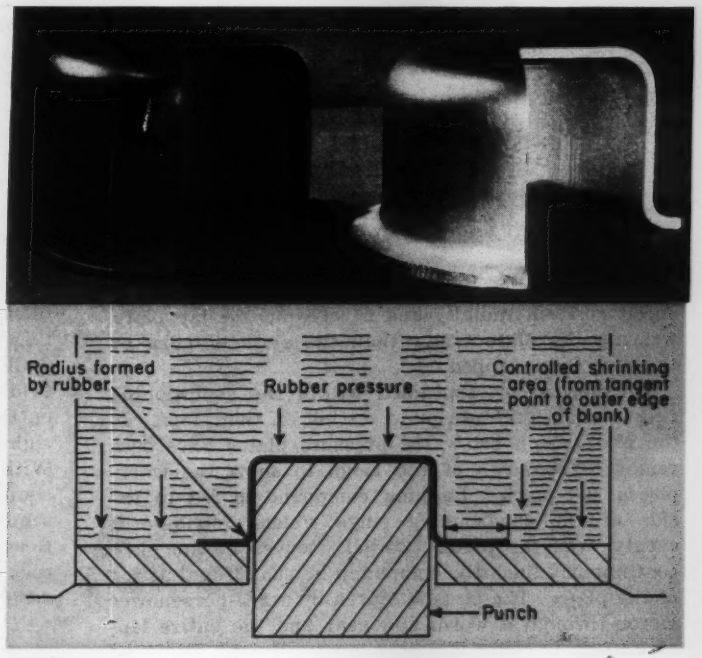
Monel that has been annealed to give uniform orientation within individual grains gives a uniform intensity of reflected light over each grain when viewed microscopically under polarized light with polarizing elements crossed for the incident and reflected beams. If the specimens have been deformed before being sectioned and polished, however, the reflected light is no longer uniform.

Effect of deformation on the grains is revealed in the photomicrographs. Initial plastic deformation takes place around a single axis. Then as the deformation increases, bending occurs about several axes. Broad bands of brightness and darkness, typified by grain *A*, appear on sections that have been sectioned longitudinally after slight deformation. Further deformation results in the bending of the crystallographic planes into a dome shape, producing areas of brightness surrounded by areas of darkness as shown at grain *B*. Deformation by twisting gives bands of brightness and darkness ending in areas of darkness and brightness, respectively, as shown at *C*. After severe necking, fully formed deformation bands are outlined in more or less irregular shapes extending mainly in the direction of flow as at *D*. Although the use of the technique has thus far been confined to Monel, the method is expected to find application in studies of plastic deformation in other metals.



Economical forming of metals is achieved by the new Marform process, producing deep-drawn parts which are uniform in wall thickness and free from wrinkles. Developed by the Glenn L. Martin Co. the method employs a male punch and a rubber pressure pad in a hydraulic press in which the pressure is controllable throughout the forming stroke of the press. Attached to the press and moved with the die is a cam which controls a valve to adjust the pressure. Shown, right above, is an operator making an adjustment on this pressure control unit.

Principle of the forming operation is illustrated in the sketch. The Marform process utilizes the same simple male punch employed in the Guerin process but it also requires rests. It is therefore unnecessary to make either a female die, pressure plate or draw ring. Elimination of the female die saves over 50 per cent of the die cost and also makes possible forming the same shape from different materials and of different thicknesses without changing the dies. At top right, are shown two parts. One is of 0.030-inch thick 1010 steel and the other is ¼-inch 61SO



aluminum, formed on the same tool by a single stroke.

Reduction in area of 57 per cent for aluminum alloys is considered normal work and figures as high as 70 per cent have been attained, whereas 40 to 50 per cent is the maximum draw for the same materials when formed on steel dies. Likewise a cup depth equal to 1½ times the radius is normally expected in the Marform process, being about 50 per cent more than that for a steel die. Material as thin as 0.01-inch thick has been successfully formed and a 0.012 cup was deep drawn to the point where the depth of the cup was 0.9 of its diameter. Gages as thick as 0.675 in aluminum alloys and 0.102 in 1010 steel have been formed.

Tension control within accuracies which were previously impossible have been obtained with the experimental hysteresis torque device shown at left. Providing simplified presetting of any tension desired, this brake applies constant tension during winding operations for yarn or fine wire. It may also be used for precisely checking torques of laboratory instruments.

In the illustration, the top of the brake is removed to show the rotor. Both rotor and stator contain Alnico magnets so designed and mounted that the magnetic restraining force on the rotor is the same at all speeds. During deceleration, momentum of the spool and spindle is absorbed, thus providing tension even after the machine is brought to rest. Engineers of General Electric's control division developed the brake.

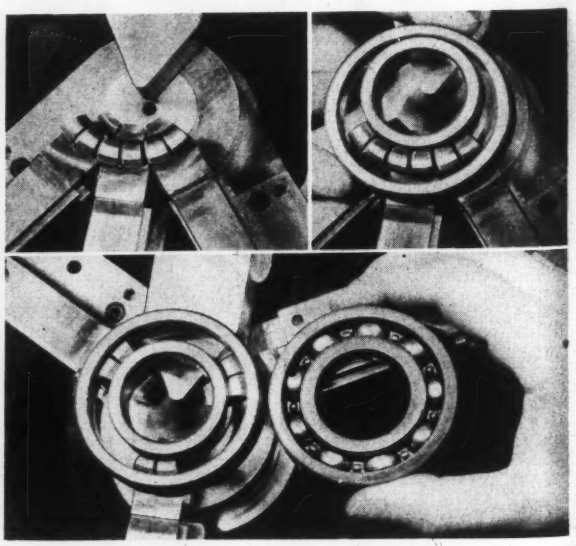
Precision lapping machine utilizes the principle of floating rings to keep the lapping plate flat, providing self-conditioning action during production operations. These conditioning rings are placed in bal-

anced position radially and revolve on the lap plate, wearing the plate faster than the plate is worn by the work being lapped.

Workpieces are contained within the conditioning rings with a pressure plate resting on their tops. In the photograph below the pressure plates have been removed from two of the rings to show the workpieces and rings. Lapping compound is fed to the side of the conditioning rings which distribute it evenly over the plate. Radial grooves in the plate continuously flush the compound by centrifugal action of the plate. The plate is driven by a 1/3-horsepower motor through a worm and gear and the entire lapping cycle is controlled by a preset timer. Designed by the Lapmaster division of the Crane Packing Co., this machine is capable of producing surfaces to flatness within one light band.

Matching inner and outer bearing races to determine the size of balls required for a bearing with a predetermined radial play is accomplished with the matching gage shown below. Matching of the races in this way effects drastic reductions in the manufacturing costs of finished parts. When races and balls are inspected separately and with 100 per cent accuracy, it is still possible that the accumulation of allowable variations will result in an error amounting to 0.0004-inch or more in the assembled bearing. Checking the races together for ball size reduces these accumulative variations, assuring precision bearings without costly rebuilding.

Close-up of the gage head, designed by the Sheffield Corp., is shown at bottom. Both races are placed on the head with the air spindles rotated so that the right and left spindles are adjacent to the lower one. With a foot pedal the operator actuates the gage for equidistant spacing, as shown, to simulate the assembled bearing in the hand to the right of the gage. Reading obtained from air jets indicates the size of the balls to be used for a bearing of the precision desired.



By Charles Lipson
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Why Machine Parts Fail

Part 1—Fracture and Inherent Strength

A BROKEN part is an expensive source of research data. But every fracture which occurs in a machine part presents to the designer an opportunity to learn more about the causes of failure and how to avoid them in subsequent designs. He should subject a broken part to the most thoroughgoing investigation in order to extract the maximum useful information from it.

In this and following articles, which are based on studies of service failures extending over several years, the recognition, classification and analysis of metal fractures will be discussed. It is hoped that these articles will serve to guide designers in the utilization of fracture information to increase the life of highly stressed machine components.

This article deals with representative causes of failure and some of the fundamentals of fracture analysis. Future articles will cover such subjects as the recognition of specific types of fracture and the identification and classification of their causes.

CAUSES OF FAILURE: A part that fails is a disappointment at best, a very serious condition at worst —and always time and money consuming. To be able to profit from such a fault is therefore highly desirable. Including causes and remedies, the following case histories of typical fractures show how extensive is the field of fracture analysis.

Stress Concentration: A typical fatigue failure of a medium carbon, nickel-chrome steel pin of 235 brinell hardness is illustrated in *Fig.* 1. The pin was

FRACTURE ANALYSIS is a valuable design tool. It is a deductive process, originating with a broken part and terminating with a definition of the causes of failure. Heretofore, no comprehensive guide to fracture analysis has been available to the designer. To fill this need, Dr. Lipson has drawn from his wealth of experience in preparing an extensive series of articles of which this is the first. We are proud to present this noted authority's pioneering work

2¼ in. in diameter, 19 in. long, with a 4 7/16-in. diameter head, 1 in. thick. Mounted inside a coil spring, it was used to connect the end bumper of an overhead traveling crane runway to its anchor fitting. The pin failed in tension when the head broke off after only a few hours of service. Examination of the part showed that failure was caused primarily by lack of a fillet at the change of section. Furthermore, the pin had not been heat treated to produce the best properties possible with the material. The remedy is obvious. Correct balance of stress and strength should be obtained by designing the pin with a generous fillet and using a properly hardened steel.

Operating Conditions: Fracture of the saw arbor illustrated in *Fig.* 2 is an excellent example of failure due to insufficient knowledge of true service stresses[1]. This case concerns the fatigue failure of several shafts used to drive a large circular saw for cutting hot bars and billets immediately after rolling. Until recently, shaft failure in this equipment was a frequent occurrence, and variations in operating conditions made it impossible to determine the average service life. For example, although one shaft lasted 26 days the new part installed in its place failed after only ten days of service. The extremely short lives of these particular shafts precipitated an investigation.

The hot-saw drive arrangement is situated on the front end of a heavy carriage which extends over the billet conveyor and acts in a vertical plane at right angles to it. The shaft is belt driven from a motor farther back on the carriage, and bearing housings are located on both sides of the central pulley on the shaft. A steel saw, 3 ft 10 in. in diameter and 5/16-in. thick, and a 24-in. diameter flywheel weighing 1100 lb, are mounted in overhanging positions at opposite ends of the shaft. Operating speed is 1450 rpm. In both instances, failure occurred at the flywheel end of the shaft. The plane of the fracture passed through the base of the radius which joins the 4-in. journal and the 4½-in. diameter section leading to the pulley. A striking similarity was noted in the character of the fractures, including the presence of temper color and advanced scoring on the 4½-in. diameter surface.

These shafts were SAE 4340 steel, heat treated to a hardness of 341 bhn. They were found to be metallurgically sound. Examination of the fractured section, however, disclosed that the shaft had been subjected to an excessive rotary bending load with a mild stress concentration. High torsional loading was also indicated. With this information on hand, the machine was examined for the following possible sources of such loading:

1. Bearing misalignment
2. Excessive belt tension, causing bending stresses in shaft
3. Excessive belt tension, causing bearing overload
4. Torsional impact, induced by saw-cutting load opposed to flywheel inertia
5. Poor lubrication, and effect of heat from hot billets on bearings
6. Vibratory stresses from heavy overhanging flywheel.

As a result of this analysis, it was believed that elimination of these failures would be accomplished by the following changes:

1. Redesign of the pulley and adoption of V-belt drive to provide higher traction and lower belt tension
2. Increase of shaft diameter in the critical area for greater stiffness
3. Substitution of a floating type of bearing as-

[1] References are tabulated at end of article.

Fig. 1—This pin failed in fatigue from stress concentration. Fillet under the head was inadequate and heat treatment, also, was improper

Photo, courtesy American Rolling Mill Co.

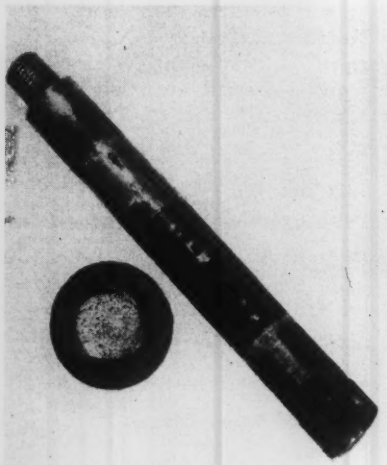
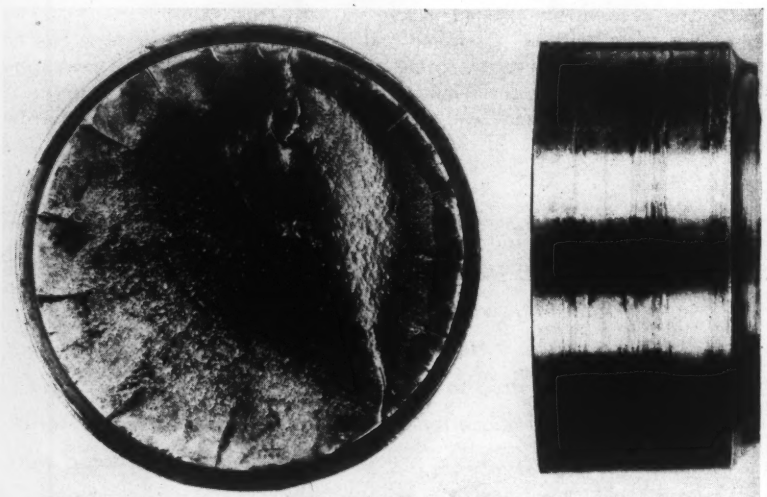


Fig. 2—Complex loading resulting from defective operating conditions caused fatigue failure of this circular-saw shaft. End view shows the extensive patterns and details that tell the story of this fracture. Side view shows location of fracture with respect to the fillet

Photo, courtesy Republic Steel Corp.



sembly using cone-shaped rollers in place of the original cylindrical type.

As the foregoing example illustrates, the cause of a failure frequently can be traced to insufficient knowledge of the actual nature and magnitude of the stresses involved. Failure is not always the result of the external forces immediately evident to the eye but of other effects produced by a variety of causes. Thus inaccuracies in manufacture and assembly, wear during service life and localized heat induce additional strains that must be taken into account.

Combined Loading: The SAE 6140 armature shaft shown in *Fig.* 3 is another illustration of a failure without obvious cause. Here, load complexities tend to obscure the cause of the failure unless the observer is familiar with this type of fracture. The 41¼-in. diameter shaft is from an electric-furnace ladle crane handling loads up to 170 tons. Failure occurred about eight inches from the brake end of the shaft. The causes of this fracture were identified as excessive combined bending and torsional loads. This knowledge leads to correction of the design or the operating conditions to prevent recurrence of the failure.

Defective Assembly: Another interesting failure is the fan shown in *Fig.* 4. This type of fan is used in automotive applications. Analysis of the failure indicates that it could have been due to any one of several causes:

1. Poor steel
2. Small cracks along the edges of the blanking, resulting from cold twisting
3. Improper assembly on pilot so that fan runs out of true.

For causes 1 and 3 the remedies are obvious. The second cause normally is eliminated by milling the edges of the spider to remove checks caused by blanking break.

Impact Loading: Fractures caused by excessive impact stresses are quite frequent in industry. Stresses involved in impact loading depend on the degree of rigidity of the assembly and can reach high values. Impact loading often occurs unexpectedly in service due to the gradually increasing clearances which appear between two mating parts as wear takes place. In this process, a simple vibrational stress changes into an impact as wear takes place, often leading to fracture of such parts as the structural members of steering gears and axle journals of vehicles. Frequently, the designer does not give sufficient attention to these stresses which, in fact, are unpredictable for many cases. But when fractures occur for no apparent reason, he should suspect these effects and make every effort to determine their magnitudes and causes.

Failures Seldom Are Metallurgist's Fault

SOURCES OF FAILURE: These few examples illustrate the fact that the vast majority of service failures cannot be traced to the metallurgist. Instead, they are responsibilities of the designer, the installation man and the service operator.

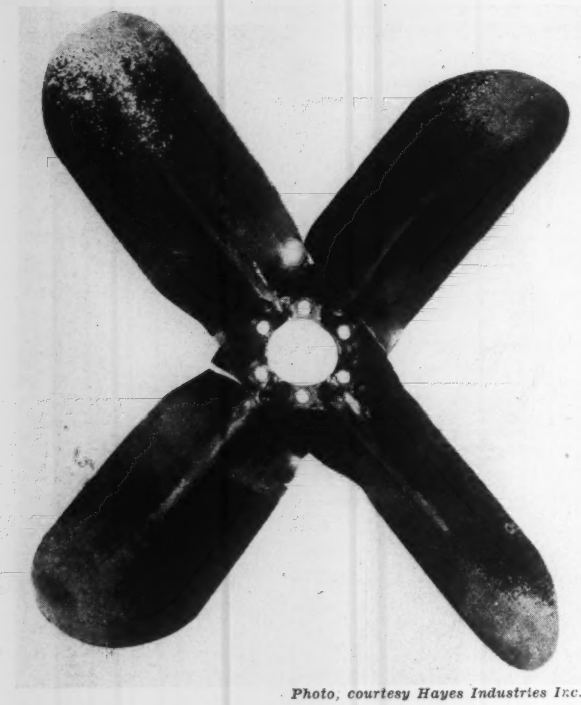
Photo, courtesy Republic Steel Corp.

Fig. 3—Combined bending and torsional loading caused fatigue failure of this armature shaft, although diagnosis was not readily apparent from the operating conditions. Appearance of this fracture is typical of bend-twist loading

This is substantiated by a number of failures examined by the author in several representative industries. Also, Arnstein and Shaw state[2] that in the majority of aircraft fatigue failures reported to date, the part has failed because of improper installation, unintentional injury to material, or imperfect features in detail design.

In another report concerning a number of representative failures in the electrical industry[3], Peterson lists three failures as due to defective manufacture (faulty forging), three to a fault in design (sharp fillet, profiled instead of sled-runner keyway, stresses due to press fit) and two to defective operating conditions (in one case, car axle journal ran hot; in the other, failure of a motor generator shaft was due to torsional resonance).

Clyne points out[4] that the majority of railroad springs fail from corrosion and decarburization, car wheels from excessive loads and stress concentration, and early railway axles from localized stresses re-



Photo, courtesy Hayes Industries Inc.

Fig. 4—Examination of this fractured automotive fan indicated failure was caused by improper assembly (out of true), poor metallurgy, or both

sulting from the press fit of the bearing on the axle. Poole and Johnson, in examining 28 failures in steel plant machine equipment, found[1] that the main causes were poor heat treatment, improper design and service abuse. Almen states[5] that fully 90 per cent of all fatigue failures can be traced to design and production defects and only the remaining 10 per cent are primarily the responsibility of the metallurgist as defects in material, material specification or heat treatment.

The following breakdown of the sources of 112 failures in the steel industry[6] illustrates the foregoing remarks:

Threads	25
Change of section in shafts	21
Sharp edges and fins (uniform section)	16
Gear teeth	9
Welds	7
Clamping stresses	6
Casting defects	5
Corrosion	5
Avoidable stressing across grain	4
Tool marks	4
Machined holes	3
Work-hardening cracks	2
Accidental injury to surface	1
Quenching cracks	1
Hot-shortness cracks	1
Heat-checking cracks	1
Inclusions	1

TYPES OF STRUCTURAL DAMAGE: In the broadest sense failure of a machine part means any action resulting from service conditions causing it to cease to function satisfactorily. Prof. H. F. Moore has classified five types of structural damage which machine parts may experience:[7]

1. *Excessive elastic deflection.* For example, a clutch plate spring may be made too light so that even when the plate spring is flattened the clutch will not transmit the required power.
2. *Elastic buckling.* Here again failure, or at least the beginning of failure, takes place within the elastic range of the materials. For example, a long slender column when compressed lengthwise will begin to buckle before the metal is stressed beyond the elastic range. The critical load at which buckling begins depends not on strength but on stiffness—modulus of elasticity—of the metal. Elastic buckling must be differentiated from the subsequent buckling that takes place beyond the elastic range.
3. *Plastic deformation.* Deformation of a machine part remaining as "set" after load is removed represents structural damage in such parts as bolt and nut connections, which become loose when loaded beyond the elastic range of the metal.
4. *Creep.* Damage by creep, the continuing distortion of a material under steady load, is similar in character to damage by plastic deformation. The difference is that creep continues while simple plastic deformation virtually stops after a short period of loading. For the common structural metals, creep is important only at elevated temperatures.
5. *Fracture.* Unlike plastic deformation or creep, which involve appreciable volumes of metal before noticeable structural damage is done, fracture may start at some point of localized stress concentration. From that nucleus it may spread to total fracture of the piece. This process occurs in brittle materials under steady load and in ductile materials under repeated stress. In the latter case the crack is due to exhaustion of the ductility of the overstressed metal and, once started, will spread even under relatively low stress.

   Such a fatigue crack often starts under shearing stress within the crystalline grains of the plastically deformed metal. When the crack spreads in a region of tensile stress it assumes a direction at right angles to the principal tensile stress. When it spreads in a region of compressive stress the crack usually follows a direction of maximum shearing stress and proceeds more slowly than it does in a region of tensile stress.

Since a fracture in a manufactured part usually follows the application of some type of excessive load, engineers have come to assume that there is a clear-cut relationship between the direction of the load and that of the fracture. For example, it is assumed that a clean tensile break results from a load tending to separate the part in a direction perpendicular to the plane of the break, while shear failure results from forces tangential to that plane. This assumption has led to the development of stress-strain relationships which are intended to serve as criteria of failure, since it is instinctively felt that fracture occurs when stress or strain reaches some critical value. But fracture always seems to start in

a *microscopic* area, and there appears to be no particular reason to suspect any real connection between such small-scale events, and stress and strain which begin to have meaning only on a *macroscopic* scale. A direct relationship may exist in certain cases, but such correlation cannot be assumed for all materials under all conditions.[8]

STRENGTH OF METALS: Metals derive their strength from the force of interatomic attraction, which by ordinary tests appears to be very large. A maximum strength of 350,000 psi has been attained in standard test pieces of some structural steels and piano wire can be drawn to 403,000 psi. However, the theoretical cohesive forces in metals as computed from the latent heat of fusion and vaporization is about 15 to 20 times the actual cohesive strength estimated from tensile tests. The interatomic forces of a metallic crystal are known with some accuracy. From them the calculated strength of a single crystal is found to be hundreds or even thousands of times the experimental values. There seem to be two reasons for the differences between the experimental and theoretical strengths of material: method of loading and surface imperfections.

Method of Loading: Method of loading plays an important part in the determination of the observed strength of tested materials. Perfectly axial loading is not always achieved in test specimens. In larger test bars the stress is not uniformly distributed over the cross section but, instead, is concentrated at some point on the surface. Fine wires seem capable of adjusting themselves to a state of uniform stress distribution, consequently show higher strengths. As an example, the tensile strength of tungsten is only 50,000 psi in a rod, but becomes 250,000 psi in wire and 700,000 psi (the greatest value for any metal known) in extremely fine wires.

Great Strength in Glass Fibers

The tensile strength of glass fibers similarly increases with decreasing fiber diameter as illustrated in *Fig.* 5. Theoretical strength of glass is 14,000,000 psi, and in very fine wire tensile strengths as high as 3,500,000 psi have been recorded experimentally.[9]

Surface Imperfections: The average test specimen has on its surface innumerable microscopic cracks from which fractures develop. The largest crack present determines the ultimate strength of the material. When a smaller test specimen is examined, the probability of its containing such a bad crack is decreased and, therefore, the observed strength should be higher. For a thin filament, the tensile strength increases inversely as the surface area.

The computed theoretical strength of rock salt is 286,720 psi with an elongation of 16 per cent. However, actual tests showed a strength of only 287 to 717 psi with a one per cent elongation. To determine whether this difference was due to surface discontinuities, the surface was dissolved off during testing. The observed tensile strength increased to 228,480 psi which agrees well with the theoretical value. As another example of the great importance of surface conditions, a filament tested in a vacuum

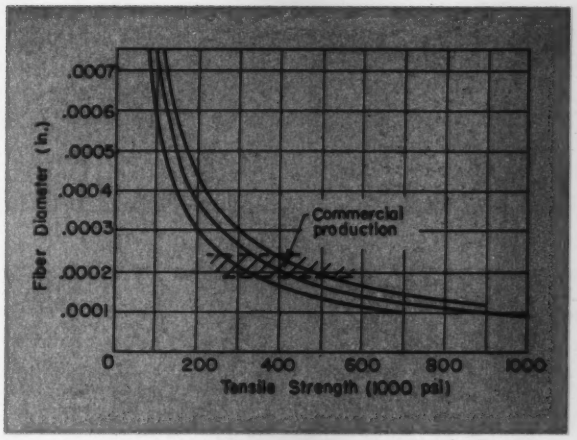


Fig. 5—Effect of diameter on strength of glass as reported by Anderegg is shown by this graph. In finer wires, stress is apparently distributed more uniformly. Note the enormous unit strength of fiber diameters approximately 0.0001-in. in diameter

was found to be five times as strong as the same filament tested in water vapor.[10]

Deformation and failure phenomena have been clarified by study of the crystalline structure of metals, and from these studies a general theory of the strength of metals and alloys has been developed. At this point a brief review of crystalline structure may be pertinent.

A metallic atom is approximately one-thousandth the size of the smallest particle that can be seen under an optical microscope. It consists of a positively charged nucleus and negatively charged electrons that revolve about the nucleus. Electrical forces of attraction between the nucleus and the electrons are balanced by centrifugal forces due to rotation of the electrons. The electrons of each atom are attracted also by the nuclei of adjacent atoms but repelled by the electrons of other atoms. These interatomic forces are largely responsible for the strength and rigidity of solid metals.

Vibration of the atoms may become so vigorous that neighboring atoms are prevented from approaching each other. In this case the metal becomes a gas due to the negligible forces of attraction between the atoms. For an intermediate condition, where the forces are appreciable but still not great enough to maintain the material in a rigid state, molten metal is formed.

In the molten condition the atoms are arranged in a random manner, but on cooling to the solid crystalline state the atoms are regrouped according to a definite pattern known as space lattice. In most metals the atoms form crystals of *body-centered* space lattice, *face-centered* lattice or, in a few cases, *hexagonal close-packed* lattice. Pattern differences are due to varying factors that are characteristic of the metal in question, including the size of the atoms, the magnitude of the electrical charge on them, the number of orbits of the electrons and the degree of completion of the outer orbit.

Malleable and ductile metals form face-centered

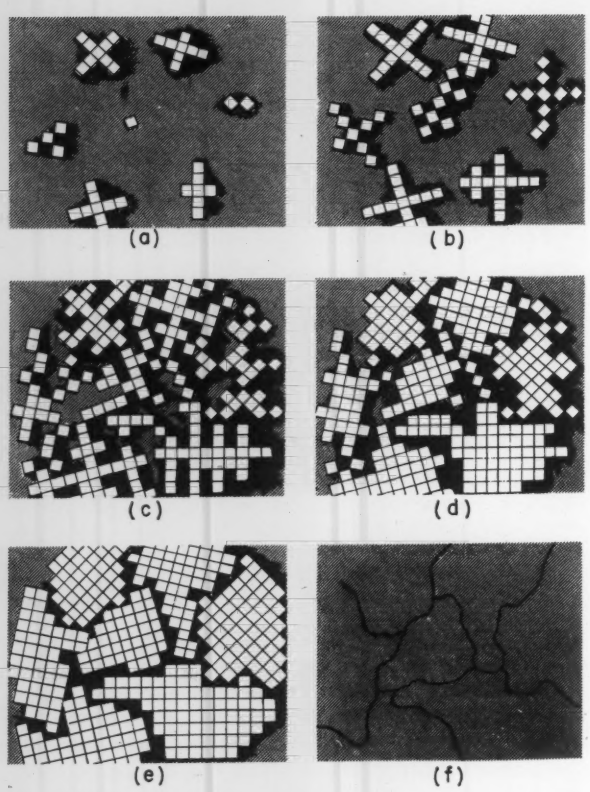


Fig. 6—Stages (a) through (e) picture the crystallographic grain growth of a metal as suggested by Rosenhain. Junction lines of adjacent crystalline growths are represented in (f). Shaded portion of (e) represents the boundary area between crystals grains. Atoms at the boundary are subjected to different electrical attraction-repulsion forces than atoms at center of grain. Thus, grain boundary properties are not the same as for crystal proper

cubic lattices while most of the nonductile metals form body-centered cubic lattices. However ferrite, a ductile metal, forms body-centered crystals.

Crystals tend to separate more readily in certain directions than in others, the directions of separation being usually parallel to the faces of the crystals. A cubic crystal, for example, splits most easily along flaws paralleling the outer surfaces of the crystal. The direction of these flaws defines the orientation of the crystal.

Crystallization: When a liquid metal solidifies, crystallization begins simultaneously at many points, each point serving as a center around which the atoms group themselves in a characteristic repeating pattern. This patterned growth continues until the outside surfaces of one crystal meet the surfaces of another similarly formed crystal. The successive stages of this crystalline growth are illustrated in *Fig.* 6.

These diagrams show the gradual growth from seven distinct centers, *Fig.* 6*e* showing the final outline when these crystalline grains meet. *Fig.* 6*f* shows the junction lines between adjacent crystalline grains as seen microscopically.

The number of crystalline grains forming a particular mass of metal depends upon the number of original centers of crystallization. In turn the number of centers is dependent on several factors: the character of the metal, the temperature of casting, the rate of cooling, and the purity of the metal. For example, slow cooling and high purity produce large crystalline grains.

Grain Boundaries: It has been found that the material in the crystalline grain boundaries is definitely stronger than that in the interiors of the grains. This condition has been explained on the basis that the boundary atoms are subjected to conflicting forces from the atoms in neighboring crystals, *Fig.* 6*e*. The shaded area represents the zone between the two lattices where the atoms are not arranged in definite patterns. This area might be regarded as supercooled liquid, like glass. It has no directional properties and is found to be strong and hard when sufficiently undercooled. It does not contain cleavage flaws characteristic of crystalline substances. Such material becomes weaker and softer at temperatures above 700 F. This property is the probable source of creep of metal at elevated temperatures.

The greater strength of a fine-grained structure, as contrasted with a coarse-grained one, has been tentatively explained on this same basis. The fine-grained metal obviously contains more amorphous areas.

In the next article of this series the origin and causes of cracks and the manner in which they propagate through the part will be discussed.

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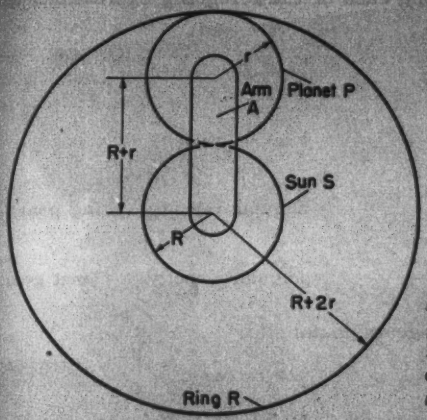

Fig. 1 — Left — Planetary set comprising single planet gear, sun gear, arm, and ring gear

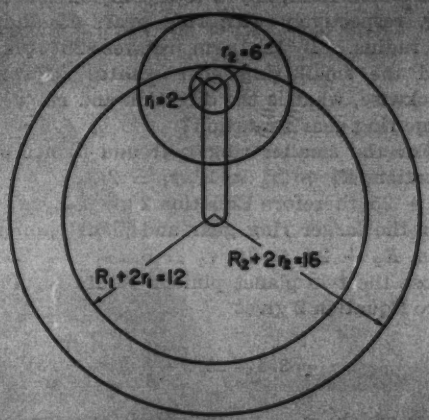

Fig. 2 — Right — Compound planetary system having a single arm carrying two planet pinions keyed to a common shaft and meshing with two ring gears

Planetary Gear Train Analysis

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NUMEROUS procedures for solving planetary gear problems are available, but the method presented here seems to be more logical and direct than most. It is based on the following four equations, which are derived in the appendix. The gear train components are identified in *Fig.* 1.

Set involving planets, P, arm A, and sun gear S:

$$\omega_p = \omega_a + \frac{R}{r}(\omega_a - \omega_s) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Set involving planets, P, arm A, and ring gear R:

$$\omega_p = \omega_a + \left(\frac{R+2r}{r}\right)(\omega_r - \omega_a) \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Set involving planets, P, ring gear R, and sun gear S:

$$\omega_r = \left(\frac{R}{R+2r}\right)\omega_s + \left(\frac{2r}{R+2r}\right)\omega_p \quad \ldots\ldots\ldots (3)$$

Set involving arm A, ring gear R, and sun gear S:

$$\omega_s = \omega_a - \left(\frac{R+2r}{R}\right)(\omega_r - \omega_a) \quad \ldots\ldots\ldots\ldots\ldots (4)$$

where

R = Pitch radius of sun gear
r = Pitch radius of planet pinion
$R + 2r$ = Pitch radius of ring gear
$R + r$ = Pitch radius of arm to center of planet pinion
ω_s = Speed of sun gear
ω_r = Speed of ring gear
ω_p = Speed of planets
ω_a = Speed of arm

In Equations 1 to 4 the radii R and r can be replaced by the numbers of teeth, N and n, inasmuch as only ratios are involved. Three examples will serve to illustrate the application of the equations.

EXAMPLE 1: A 3-inch sun gear rotates 15 rpm clockwise while an arm carrying a 2-inch planet pinion rotates 40 rpm clockwise. What is the direction and magnitude of the absolute angular velocity of the planet pinion? Substituting in Equation 1 the values $\omega_a = +40$, $R = 3$, $r = 2$, and $\omega_s = +15$, it is found that $\omega_p = +77.5$, the plus sign indicating the same direction (clockwise) as ω_a and ω_s.

EXAMPLE 2: A 7-inch ring gear rotates at 25 rpm counterclockwise while the arm carrying a 2-inch planet pinion rotates at 30 rpm clockwise. Find the magnitude and direction of the absolute angular velocity of the planet pinion. Substituting in Equation 2 the values $w_a = +30$, $R + 2r = 7$, $r = 2$, and $w_r = -25$, it is found that $\omega_p = -162.5$, the minus sign indicating the same direction as ω_r (counterclockwise).

EXAMPLE 3: A compound planetary system, *Fig.* 2,

has a single arm carrying two planet pinions, with 2 and 6-inch radii, keyed to a common shaft and meshing, respectively with ring gears 12 and 16 inches in radius. If the arm rotates 25 rpm clockwise and the small ring gear rotates 30 rpm counterclockwise, what is the direction and magnitude of the large ring gear's rotation?

For the smaller ring gear and planet pinion combination, $R_1 + 2r_1 = 12$, $r_1 = 2$, $\omega_{r1} = -30$, and $\omega_a = +25$, therefore Equation 2 gives $\omega_{p1} = -305$ rpm. For the larger ring gear and planet pinion combination, $R_2 + 2r_2 = 16$, $r_2 = 6$, $\omega_{p2} = -305$ rpm (because the two planet pinions rotate together), therefore Equation 2 gives

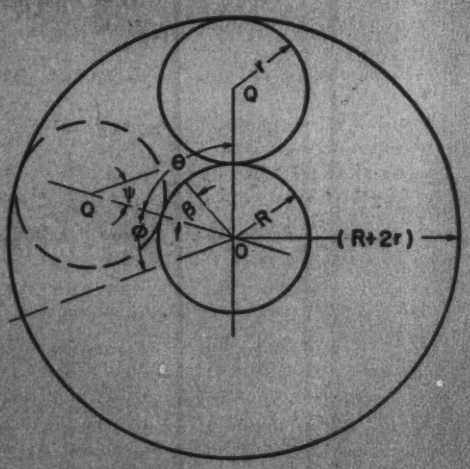
$$-305 = 25 + \frac{16}{6}(\omega_{r2} - 25)$$

from which $\omega r_2 = -98.7$ rpm (counterclockwise)

Appendix

To derive the basic Equations 1, 2, 3, and 4, refer to *Fig.* 3. First consider the ring, sun, and planet gears and the arm as being locked. The locked set is then rotated through angle θ about center O. Next, with the arm stationary in this new position, the

Fig. 3—Planetary set with angular movement of train components indicated to aid in derivation of basic equations



planet gear is rotated through angle ψ about its center Q. While the planet gear is being rotated through angle ψ (the arm being stationary), the sun gear rotates through angle β, and the ring gear rotates through angle ϕ. Then

Arm has moved through angle θ
Sun gear has moved through angle $\theta - \beta$
Ring gear has moved through angle $\theta + \phi$
Planet gear has moved through angle $\theta + \psi$

The absolute angular velocities can be obtained by differentiating each of the foregoing expressions with respect to t.

$$\omega_a = \frac{d\theta}{dt} = \text{angular velocity of arm}$$

$$\omega_s = \frac{d\theta}{dt} - \frac{d\beta}{dt} = \text{angular velocity of sun gear}$$

$$\omega_r = \frac{d\theta}{dt} + \frac{d\phi}{dt} = \text{angular velocity of ring gear}$$

$$\omega_p = \frac{d\theta}{dt} + \frac{d\psi}{dt} = \text{angular velocity of planet gear}$$

Since the gears do not slip:

$$R\beta = r\psi$$

$$(R + 2r)\theta = r\psi = R\beta$$

The foregoing six equations can be combined to give:

$$\omega_s = \omega_a - \left(\frac{R + 2r}{R}\right)\frac{d\phi}{dt}$$

$$\omega_R = \omega_a + \frac{d\phi}{dt}$$

$$\omega_p = \omega_a + \left(\frac{R + 2r}{r}\right)\frac{d\phi}{dt}$$

The parameter $d\phi/dt$ can be eliminated from the above three equations, resulting in Equations 1, 2, 3, and 4, Page 101.

They Say . . .

"Too many have learned too late that people buy what they *need*—not what they want. In the final analysis it is the needs of the customer that determine the specifications we engineers must write."—HAROLD T. YOUNGREN, *Ford Motor Co.*

"The belt conveyor and related heavy conveying techniques will undergo their greatest technical development in history in the next ten years. The conveyor era is just unfolding and its possibilities are unlimited"—HAROLD VON THADEN, *vice pres. and Gen'l Mgr., Robins Engineers Div., Hewitt-Robins Inc.*

"The social effectiveness of the engineer is today almost entirely indirect. He develops, in general, what his employer wants, whether that employer is a government or a private corporation. He has little concern whether his products are utilized for general welfare or for violent destruction"—JOHN MILLS.

"Keep on going and the chances are that you will stumble on something, perhaps when you are least expecting it. I have never heard of anyone stumbling on anything sitting down"—CHARLES F. KETTERING.

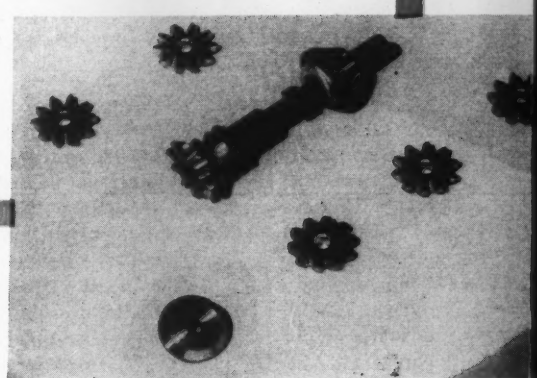
Fig. 1—Left—View of the Friden STW-10 Ultra-Matic calculator

Fig. 2—Below — Accumulator shaft bevel gear assembly and views of the die-cut gears

Designing for High Production

. . . and reduction in production costs

By John L. Moody
Research Engineer
Friden Calculating Machine Co. Inc.
San Leandro, Calif.



HIGHLY competitive conditions in the field of office machines and calculators have made mandatory low initial unit costs in production to achieve and maintain high-volume sales. Designers of such equipment, *Fig.* 1, must analyze, redesign and conceive continually to assure maximum economy in manufacture. To realize this end the utilization of high-production, low-cost manufacturing methods, minimum number of parts, maximum interchangeability, and most suitable materials are all-important.

It has been said that "necessity is the mother of invention". By the same token it seems to be a law of mechanical design that when one is forced into a simple design from necessity, it often happens that this course should have been the one taken initially even though the criterion of necessity did not exist. In the following paragraphs a number of complex calculator parts will be illustrated and discussed to show how design has been simplified or changed to obtain the cost advantage of more economical production methods, to increase production output, or to eliminate costly and time-consuming operations.

The bevel gear shown in *Fig.* 2, one of which is used on each of the twenty accumulator dial shafts, was originally blanked on an automatic screw machine and then placed on an index fixture of a milling machine where the ten teeth were cut one at a time. This comparatively slow procedure was eliminated by adapting the design for production on the punch press, all ten teeth being cut simultaneously. Cutters are set in the head at an angle of 25 degrees to the vertical, and cut at a reverse angle in the $\frac{5}{16}$-inch diameter bronze blank.

Another example of conversion from slow to high production is the counter-rocker cam shown in *Fig.* 3 at *a*. Action of this cam had to be a quick move-

ment with a dwell and a quick return with a second dwell. The plate or face cam shown performed this function very well but, due to the milled cam groove, its cost was prohibitive. This design was discarded in favor of the partial square motion cam shown at *b*, made of punch press parts, which cost less than 10 per cent of the face cam type. Similar redesign for high production is now being contemplated for a counter-oscillating cam which is of the drum type with two programming grooves on the periphery.

The "clear" racks for clearing the dials of the calculator, shown in *Fig.* 4, were formerly made of one long section of brass with milled teeth and relieved sections, as at *a*. These are now designed as shown at *b* by using two thin strips of brass, with die-cut rack teeth, riveted together at the correct spacing. This change resulted in a part cost saving of 90 per cent.

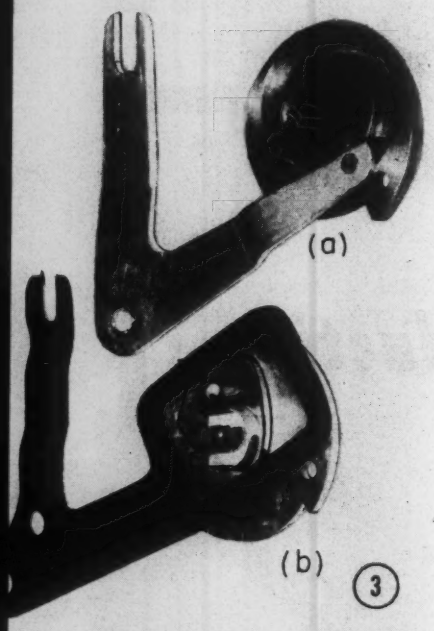


Fig. 3—Counter-rocker cam designed for press production as at (b) reduced cost more than 90 per cent over the original machined job (a)

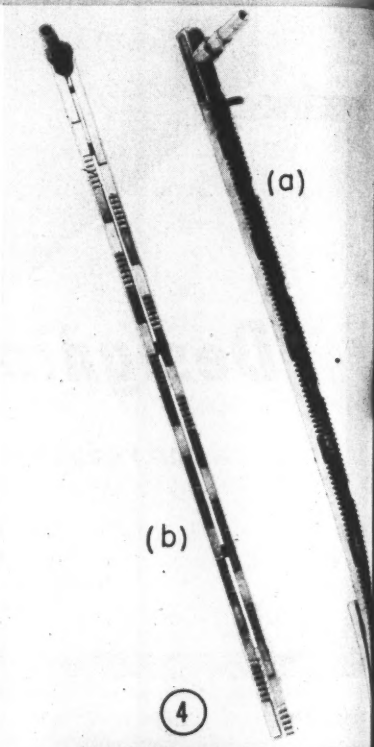


Fig. 4—Racks for clearing the calculator dials designed for press production as at (b) reduced cost 90 per cent over the original milled rack (a)

Fig. 5—Simplified design of counter-reversing lever and cam

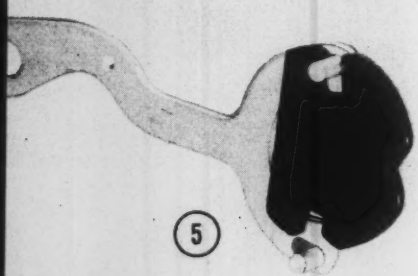


Fig. 6—Drilling, tapping and ball assembly operations for the overload clutch (c) are eliminated with the stamped design shown at (d)

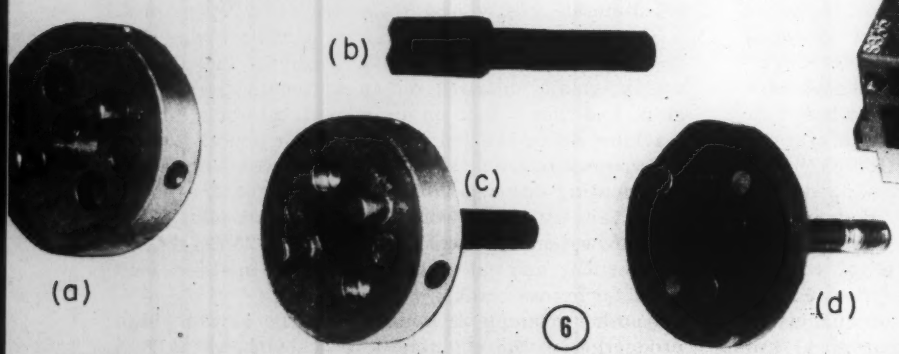
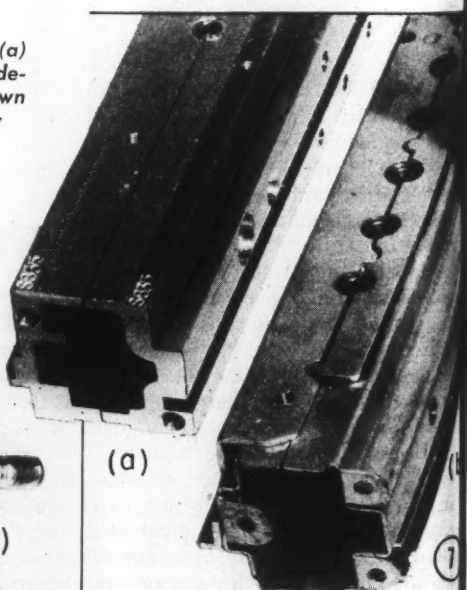


Fig. 7—Original carriage frame (a) of extruded shapes has been redesigned for press production as shown at (b) in the photograph below



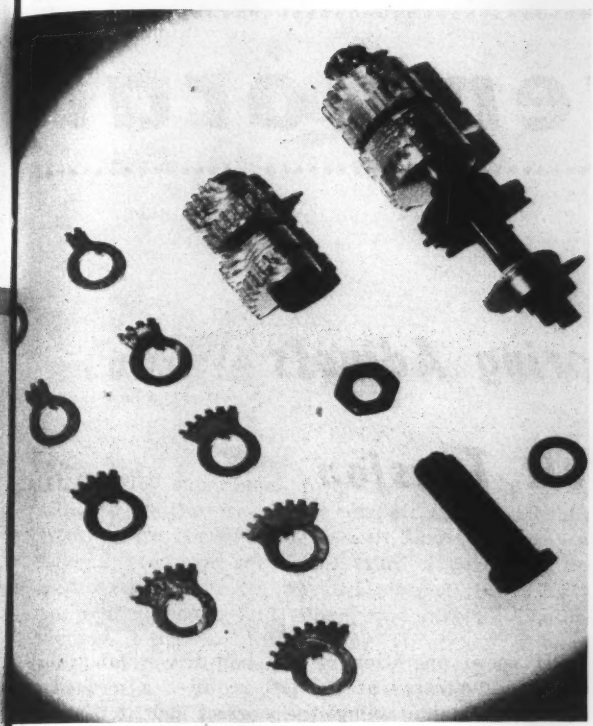


Fig. 8—Conversion from solid milled design of actuator segments to design built-up from stampings reduced production costs over 90 per cent

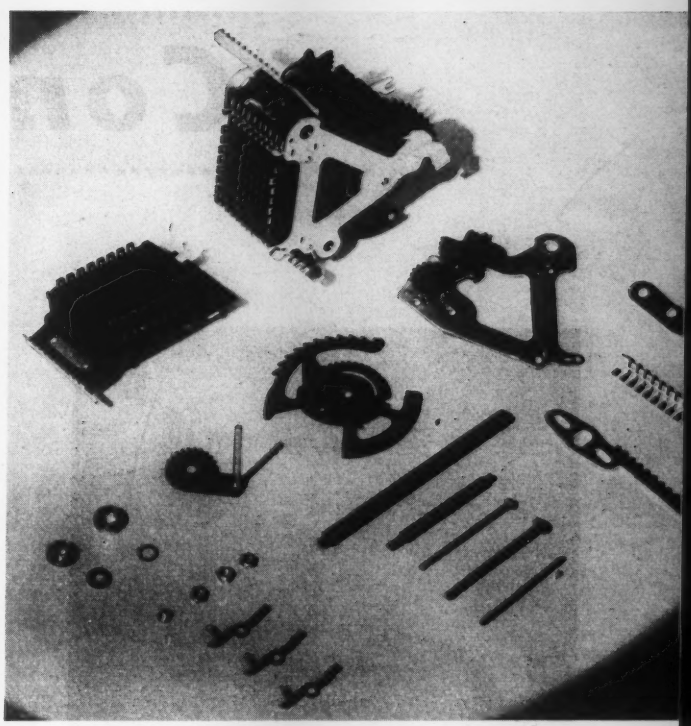


Fig. 9—Multiplier unit assembly and basic parts employed in its construction. High interchangeability of components is achieved in this design

Design for simplified press production is also well illustrated by the part in *Fig.* 5, a counterreversing cam and actuator lever. This was formerly a one-piece cam and lever arrangement that was extremely difficult to manufacture due to the peculiar mechanical movement necessary. In this action, a longitudinal oscillation of the light-colored lever must rock the shaft through the disk assembly either in a clockwise or a counterclockwise direction. With the simplified version, this is accomplished by rocking the left end of the lever vertically so that either its upper or lower pin is lodge in its respective actuating slot in the disk.

Assembly Operations Eliminated

Another example of economical redesign is the overload clutch, *Fig.* 6. This was formerly a die casting as shown at *a,* with four drilled and tapped holes equally spaced around the periphery. These holes contained balls, backed up by springs, that co-operated with four milled grooves in shaft *b,* shown assembed into the die-cast part at *c.* All drilling, tapping and ball assembly operations were eliminated by the redesign of this overload clutch as shown at *d.* Made entirely of punch press and screw machine parts, even the two grooves on the larger diameter head of the shaft are cut by dropping the shaft into a die and punching them out instead of using more costly milling methods.

The carriage frame shown at *a Fig.* 7, made of an extruded aluminum shape with considerable milling, has been redesigned experimentally into a complete punch press job as shown at *b.* The dial bearing holes are fabricated into a double thickness to gain more bearing surface. The overlapping extra thicknesses of metal also serve to lock the two frames together and locate them relative to each other.

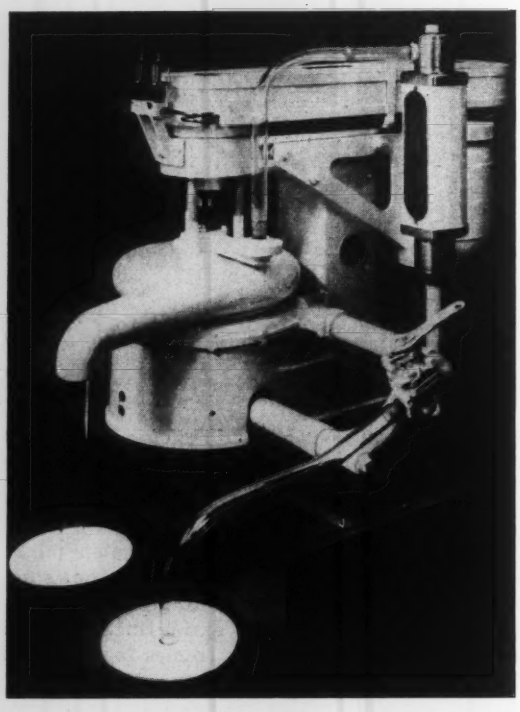
Actuator segments which transfer amounts from the keyboard to the dials, *Fig.* 8, were also converted from a solid aluminum drum with milled teeth to stacked punch press segments which come off the dies complete with teeth, holes and keys. This also cut cost more than 90 per cent.

All newly designed mechanisms are thoroughly checked before being released for production, to determine whether or not every part possible is designed for low-cost press or screw machine production. A check is also made to determine whether or not multiple parts are being used to best advantage. A good example of this is the multiplier unit, an assembly of which is shown in *Fig.* 9 with an exploded view of the several different and multiple parts employed.

Tremendous Untapped Possibilities

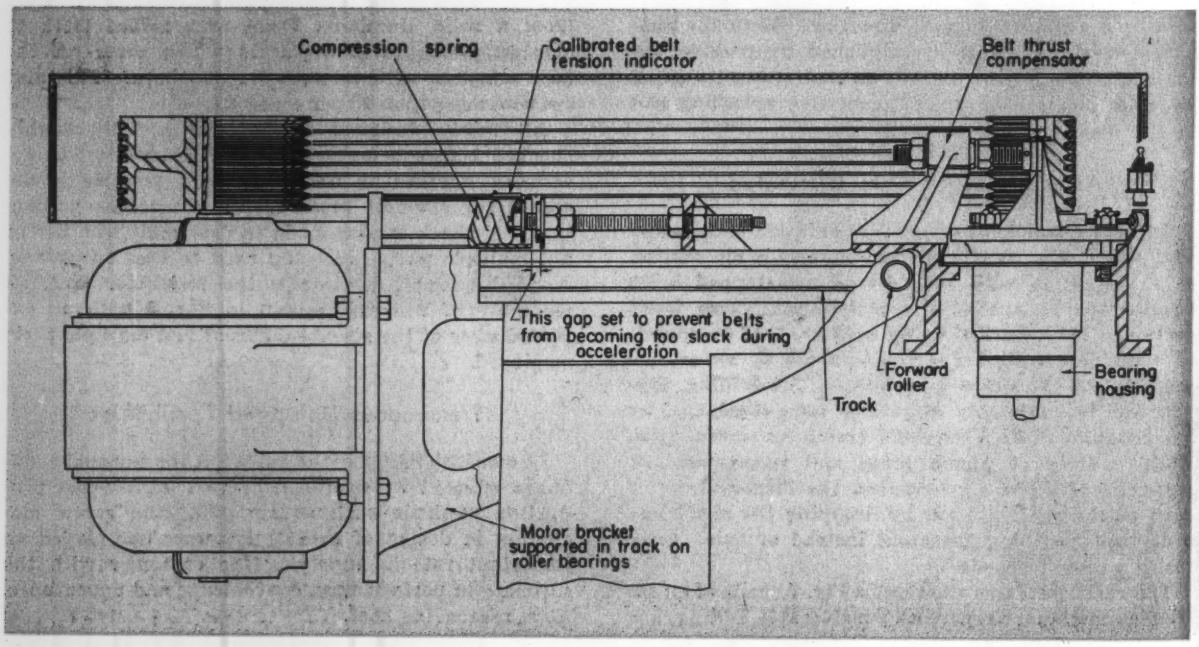
In conclusion, it may be said that the unusual economies effected by astute utilization of low-cost production methods such as stamping and screw machining in design of these calculators has played an important role in supplying the customer with the ultimate in performance, convenience and appearance, at a reasonable cost.

Contemporary



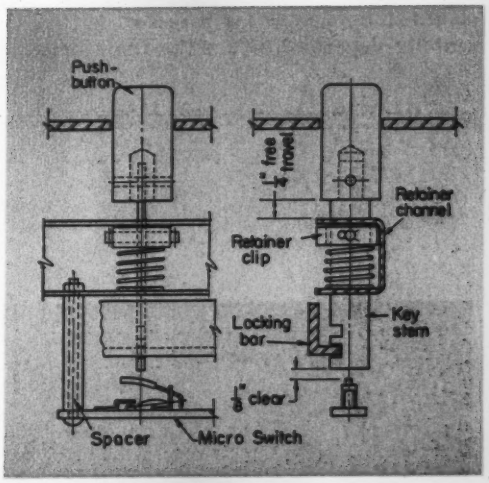
Spring Adjusts Belt Tension

HIGH speed operation of the belt-driven laboratory centrifuge illustrated at the left requires a method of applying and maintaining the correct belt tension in order to effectively transmit the necessary horsepower. The motor is mounted on a bracket which is supported in a track by roller bearings. The required running tension is applied to the belts through a compression spring, so that the motor is free to move a small distance against spring compression to compensate for a sudden change in load, as during starting. The centrifuge is driven at 9000 rpm by a 15-hp motor through five steel cable V-belts running at 7300 fpm, and has a capacity of 1 to 20 gpm. Manufacturer: Merco Centrifugal Co., San Francisco, Calif.


Compression spring
Calibrated belt tension indicator
Belt thrust compensator
This gap set to prevent belts from becoming too slack during acceleration
Forward roller
Track
Bearing housing
Motor bracket supported in track on roller bearings

Design

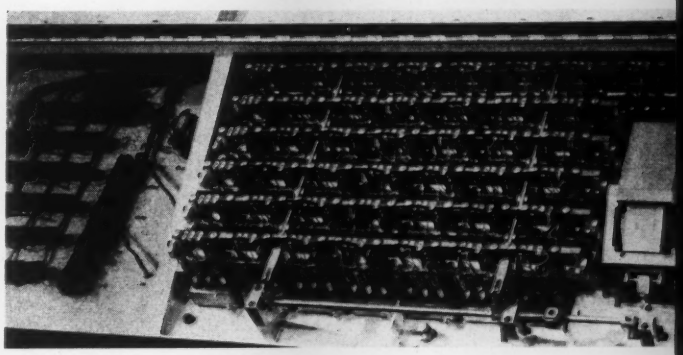
Console Controls Sorting

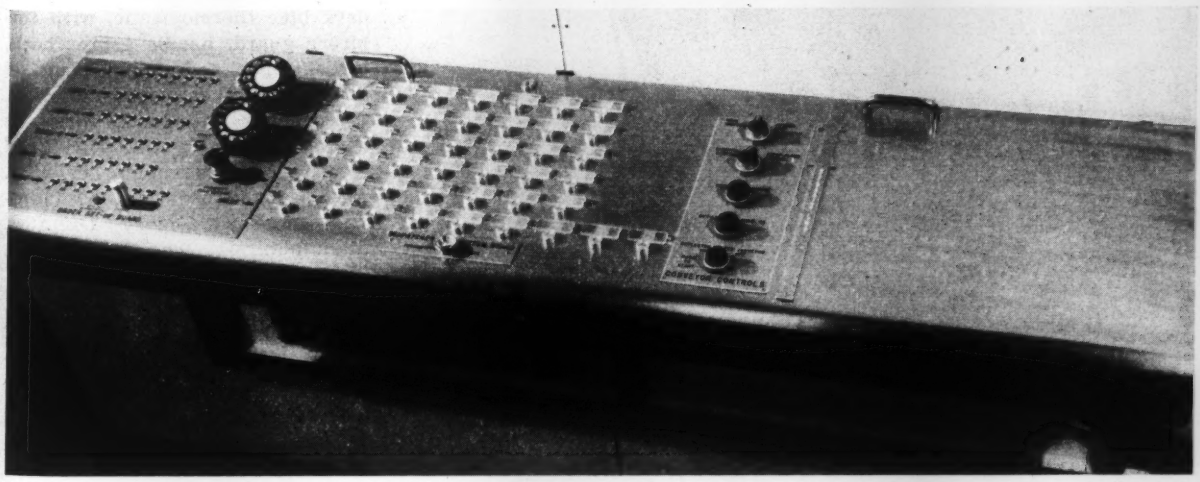


REMOTE supervision over the sorting of barrels is provided with the warehouse dispatching desk shown below. Appropriate controls route each barrel into the storage or holding conveyor set up to store a particular order. The control desk includes an order set-up board, a dispatcher pushbutton board and conveyor controls. The left section records details of forthcoming orders on a barrel-counter panel. To set the board up, a plug is inserted in the hole representing the desired storage conveyor. Two telephone type dials and a pushbutton are used to set up the proper number in the window of the barrel-counter panel—the top dial setting units, the bottom dial tens and the button setting hundreds.

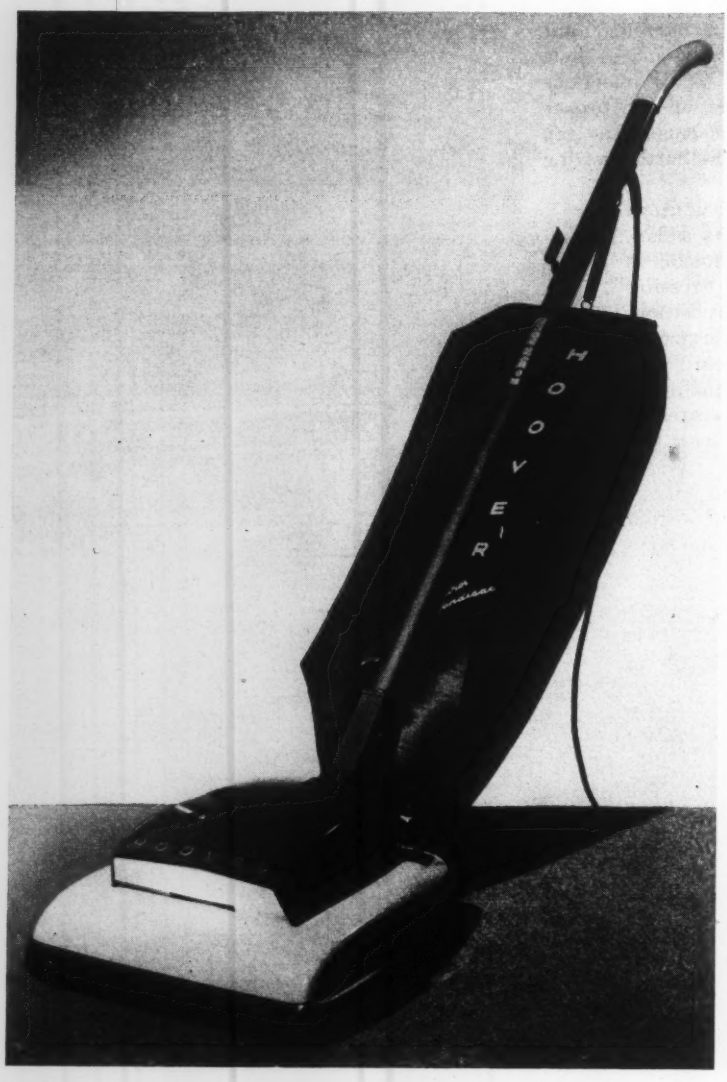
The center section of the console has a pushbutton corresponding with each lateral conveyor. As a barrel approaches the desk, the appropriate button is pushed to route it to its correct conveyor. Pressing any button on this section locks the board in position. When the barrel passes the console, it de-energizes a phototube-controlled relay to unlock the board and permit routing of the next barrel. Depressing the pushbutton starts a timing mechanism which operates in synchronism with the barrel movement to divert the barrel into the proper storage conveyor.

An interior view of the console is shown at the right. The setup board is at the left with the switch bank at the right. The locking mechanism operates





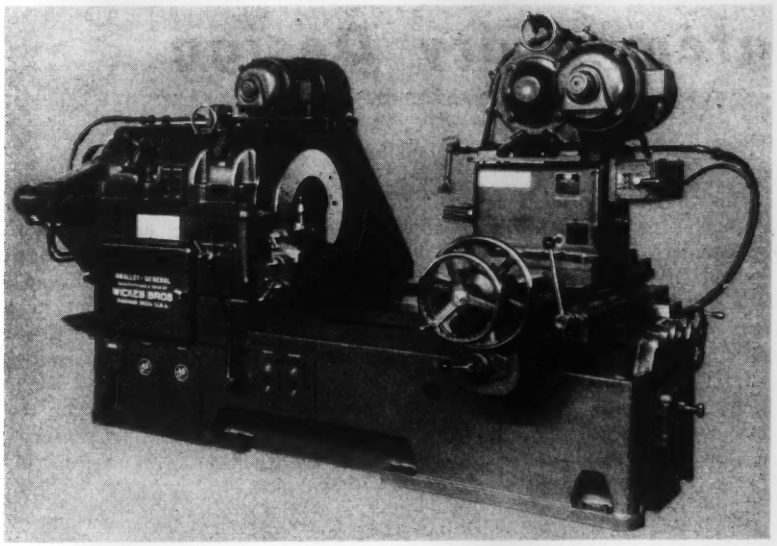
through the rod and linkage seen at the front, which is actuated by the solenoid at the right. The drawing, top of previous page, is a section through one of the L-shaped locking bars which are advanced into one of the two slots on the pushbutton stems to lock them in either up or down position. This locking makes it impossible for a second button to be accidentally depressed before the timing mechanism has been started, thereby preventing misrouting. A glass plate next to each pushbutton covers three colored pilot lights which provide a continuous indication of the status of the order related to that button. The top of the glass plate is sand blasted to give a surface suitable for writing in the identification of each order destination. Manufacturer: Beckman & Whitley Inc., San Carlos, Calif.



Plastics Enhance Styling

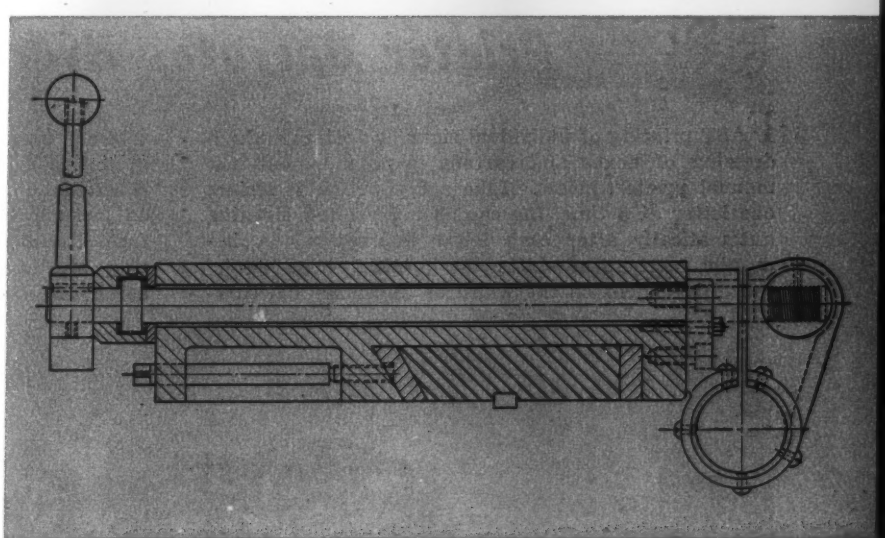
INCREASING use of plastics in consumer products is demonstrated in the upright type vacuum cleaner, left. Motor hood is made of a dark blue thermoplastic, with furniture guard, handle grip, wheels, attachments and other parts of Vinylite or other plastic materials. A cleaning attachment hose is made of a vinyl plastic over coiled steel wire for maximum flexibility. The cleaner was styled by industrial designer Henry Dreyfuss. Manufacturer: The Hoover Co., North Canton, O.

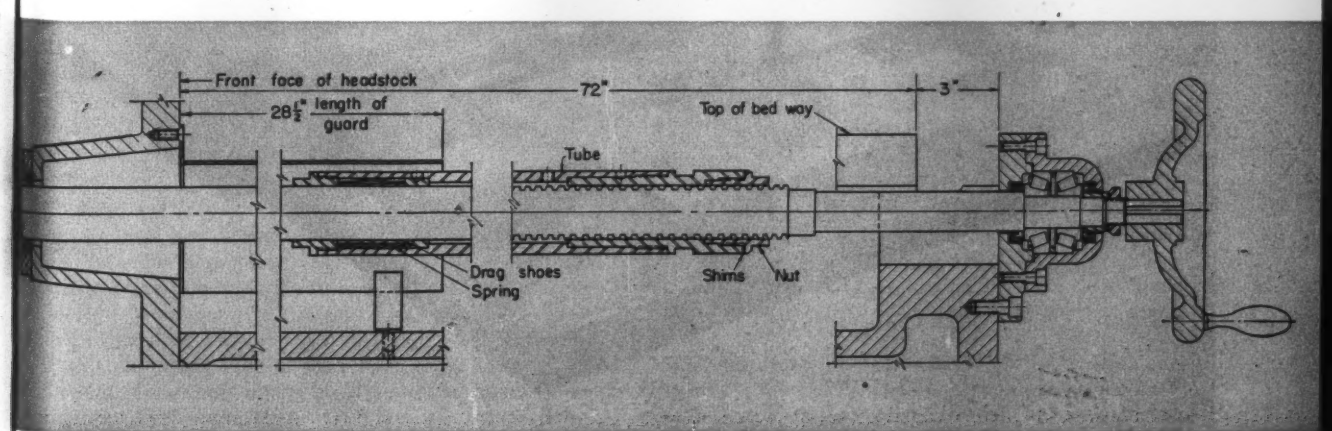
Utilizes Precision Feed Mechanism



MOST recent design of the No. 30 Smalley General thread miller, right, employs an interesting feed mechanism. The lead screw, located in the center of the machine bed, is 2 inches in diameter and has a thread about 20 inches long. On this ¼-inch pitch thread is mounted a two-part cast iron nut shown in the drawing below. Laminated shims between the two parts of the nut permit wear adjustment. The nut is mounted inside a ground tube about 4 feet long. In the opposite end of the tube, spring-held drag shoes press against the unthreaded part of the lead screw and tend to turn the tube with the screw.

The tube passes through a clamp, drawing right, attached to the bottom slide of the milling head. In its open position, the clamp clears the tube by a few thousandths so that the tube rotates with the lead screw. When the clamp is tightened, the tube can no longer turn; the tube then acts as a nut and



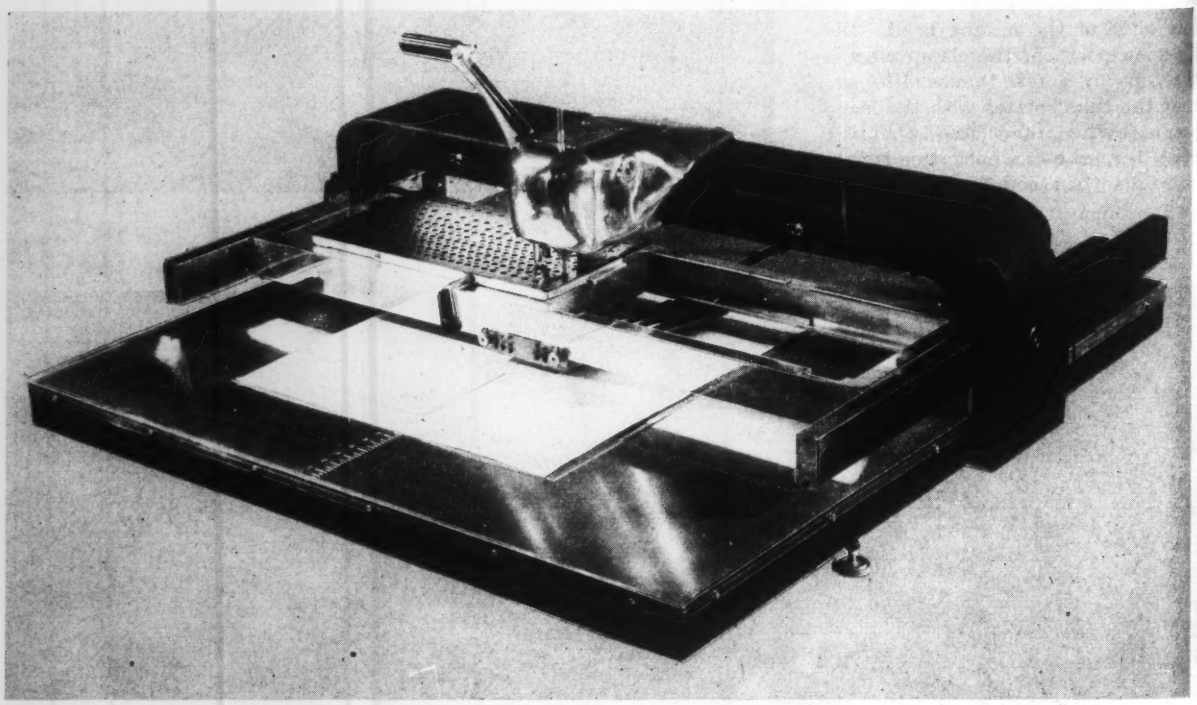


carries the milling head with it. This travel causes the cutter to track at the speed to mill the desired helix angle.

After the tube has been run to the end of its travel, as might happen once or twice a day, it is returned to the starting position by turning the handwheel at the end of the machine or by running the main spindle in reverse. During this return, the clamp must be partially closed to prevent rotation of the tube while allowing longitudinal movement of the tube through the clamp. If the tube is allowed to run off the threads in the feeding direction, no damage can occur. This feed mechanism has the feature of minimizing lead error—the error in lead of a ¼-inch pitch thread, assuming the lead screw 0.010-inch per foot out in lead, is 0.0002-inch. The machine has 10½ or 15½-inch hydraulically-operated 3-jaw wedge chucks, milling spindle speeds from 50 to 300 rpm, and main spindle speeds from 1.52 to 41 minutes per revolution for milling and 3.08 to 83 rpm for turning. Manufacturer: Wickes Brothers, division of the Wickes Corp., Saginaw, Mich.

Printer Operates Hydraulically

FAST printing of individual signs or posters and addressing of boxes and cartons is possible with the manual printer, below. Like a typewriter, it strikes one letter at a time, the card being printed indexing automatically after each letter impression. A hydraulic mechanism shifts the printing head a distance dependent on the width of the individual characters. About 15 words per minute can be printed in various types and in sizes from ⅛ to 2 inches high. When used on boxes or cartons, the head is placed on jacks to hold it in position over the printing surface. It will print on any surface regardless of thickness, size or quality. Manufacturer: Reynolds Printasign Co., Chicago, Ill.



By Roger W. Bolz

Associate Editor, Machine Design

PLASTICS MOLDING

AMONG the basic engineering materials widely utilized and accepted today, plastics have attained a firm place. As with any specific material or materials, plastics in general are no panacea for design problems. On the contrary, unless the necessary degree of care is exercised in their application, disappointing results may lead to false impressions regarding their many possible advantages.

As is characteristic with other methods of production, where machining, handling, fitting, assembling, and finishing operations can be minimized or eliminated, plastics molding may prove highly economical, *Fig.* 1. The critical design consideration thus is largely that of suitability of the material for the application.

The suitability factor cannot be overemphasized. Properly applied, plastics materials provide a host of unusual properties which suit them for a wide range

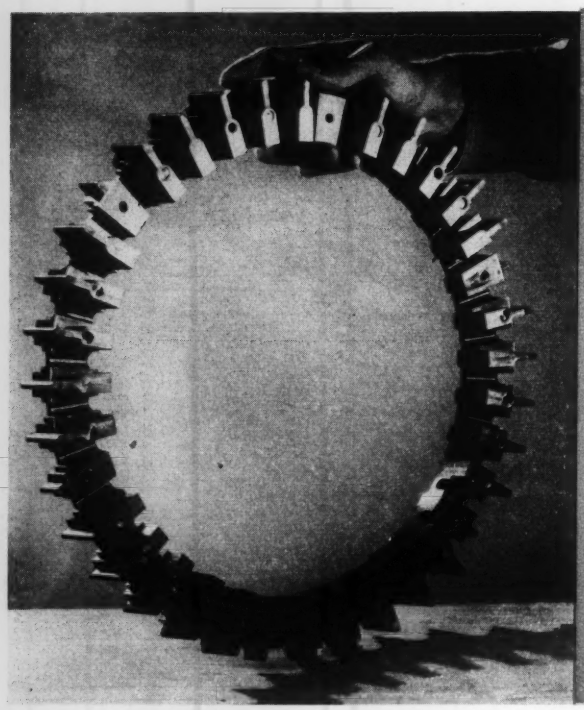


Fig. 1—Left—Phenolic molded dispenser ring for an ice cream vending machine. Molded parts reduced weight by 30 pounds and cost by $313 on each unit

Fig. 2—Right—Group of typical molded, laminated and laminated molded phenolic parts

of uses. Generally, plastics are strong, light, highly dielectric, workable, corrosion and chemical resistant, and durable. Satisfactory applications range over a wide variety of machine parts from handwheels, gears and levers to housings, frames and insulators, *Figs.* 2 and 3. Plastics are definitely *not* a substitute material; their adoption to achieve lowest possible cost in any design should include the requirement of one or more of the unusual and wide variation in properties available only with plastics materials.

TYPES OF PLASTICS: The multitude of types of plastics now available for use in design can be broken down generally into two basic categories: (1) Thermoplastic and (2) thermosetting plastics. The thermoplastics, as the name indicates, are heat-softening. After heating, forming and cooling, they can be remelted again. On the other hand, thermosetting plastics are heat-hardening and, once having been molded under heat and pressure, the synthetic polymerizes into a dense, hard infusible mass that cannot be remelted.

FORMS OF PLASTICS: For convenience, plastics may be subdivided into several basic forms according to the means by which parts are produced. Generally, these are: (1) Molding, (2) laminating and (3) casting. Each of these methods of making finished plastics parts consist of several or more variations which permit a wide selection and extend the practical possibilities in design. Casting has been utilized mostly for decorative articles and the limited applications possible for machine parts make its consideration in this article unnecessary.

The various useful molding method subdivisions and their area of materials or design application are generally as follows:

1. Compression	Thermosetting; powder or preform with paper or cloth fill.
2. Transfer	Thermosetting; complicated designs with delicate cores, inserts, sections, etc.
3. Injection	Thermoplastics; powder form.
4. Extrusion	Thermoplastics; tubes, rods, sheets, shapes, etc.
5. Cold	Refractory and nonrefractory; resistance to high heat and arcs.
6. H. P. Laminated	Thermosetting; paper and cloth-filled phenolics, high strength, electrical properties, deep draws.
7. L. P. Laminated	Thermosetting; wood, paper or cloth-filled phenolics for large size and low-cost work.

Compression Molding: In compression molding a material, normally in powder or preform shape, it is loaded directly into the hot die cavity. Pressure from 2000 to 10,000 psi is applied, held for a curing period, and then the finished part is ejected. Time for polymerization or curing depends upon the design, small thin-wall pieces requiring as little as 20 seconds.

In compression molding, the "force" or compressing member of the open mold forms one of the finished surfaces of the molded part, *Fig.* 4. This method is largely utilized for molding thermosetting materials.

Transfer Molding: Transfer molding was developed largely to avoid the disadvantages found with compression molding. Unlike compression molding, the dies are closed and the force does not form any of the molded surfaces. Powder, pellet or preform material is loaded into a separate cylinder and, under heat and pressure of approximately 15,000 psi, is

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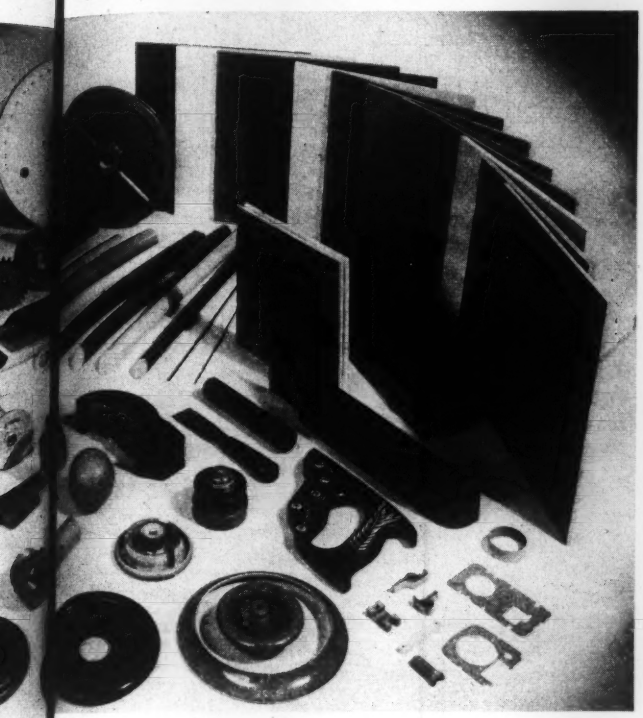


Fig. 3—Multiple-spool, drum sections, "cheese" core barrels, and sleeves of this Barber-Colman automatic yarn spooler are molded of general-purpose phenolics

transferred or injected into the closed dies, *Fig.* 5. Curing time required after transfer is but one-third of the compression molding curing time.

Employed for producing thermosetting plastics, transfer molding permits the use of intricate inserts and slender cores not practicable with the compression method. Duplex or plunger molding, *Fig.* 6, is considered most economical. A more recent development, jet molding, brings the transfer method closer to injection molding as used for thermoplastics. The plastic material is forced by ram or screw through a heated jet where it becomes soft before entering the closed die. Good flowing materials with a long flow period are desirable.

Injection Molding: Most successful and widely used method for molding thermoplastics, injection molding dies are chilled to solidify the molten plastic material into final shape. Granulated material is fed from a hopper, in measured amounts, to the heating chamber where it attains a fluid consistency. The softened plastic is then automatically injected into the dies by means of a plunger, *Fig.* 7. After a short cooling period, the dies open and eject the completed solidified piece or group of pieces.

Speed of production with injection molding is enhanced by the fact that no curing time is required. The speed also results in lower mold costs, fewer cavities being necessary for a specific output. Other features which have helped make injection molding popular are: (1) Less material loss, gates and runners can be reused; (2) fewer finishing operations, flash characteristic in compression molding is eliminated; and (3) high thermal efficiency, the heating chamber and mold remain at constant temperatures.

Extrusion Molding: Molding of plastics by continuous extrusion is not unlike ordinary extrusion methods. Granular material is fed by hopper into a heating cylinder through which it is forced by a screw into a heated shape die. Continuous lengths are produced at a rate of 500 to 1000 feet per hour, the hot material cooling and hardening on the take-off belts.

Die requirements are relatively inexpensive and equipment is much simpler than for the other meth-

Table 1—Limitations on Small Cored Holes
(inches, see *Fig.* 15)

Hole Diam, A (Min)	Blind Depth B (Max)	Thru Depth C (Max)	—Side Walls D (Min)— Hot Molded	Cold Molded	Hole Spacings E (Min) Hot Molded	Cold Molded
1/32	1/32	1/8	1/32	1/32	1/32	1/32
1/32	1/32	1/32	1/32	1/32	1/32	1/8
1/32	1/8	1/8	1/32	1/32	1/32	1/8
1/32	1/32	1/32	1/32	1/8	1/8	1/32
1/8	1/32	1/8	1/32	1/8	1/8	1/32
1/32	1/8	1/8	1/32	1/8	1/8	1/32
1/32	1/32	1/8	1/8	1/32	1/32	1/8
1/8	1/32	1/8	1/8	1/32	1/32	1/32
1/32	1/32	1/8	1/32	1/8	1/8	1/32
1/8	1/32	1/8	1/32	1/8	1/8	1/32
1/32	1/32	1/8	1/32	1/8	1/8	1/32
1/8	1/32	1/8	1/32	1/8	1/8	1/32

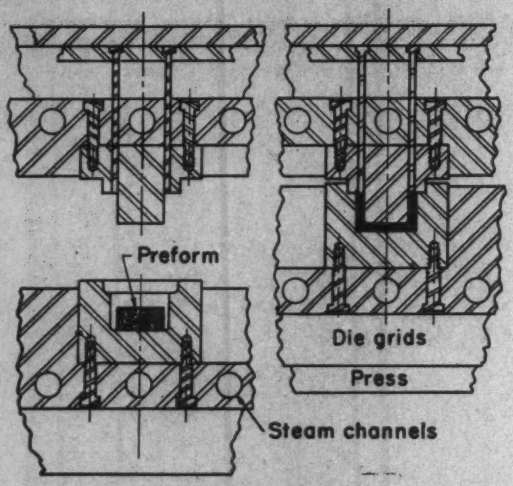
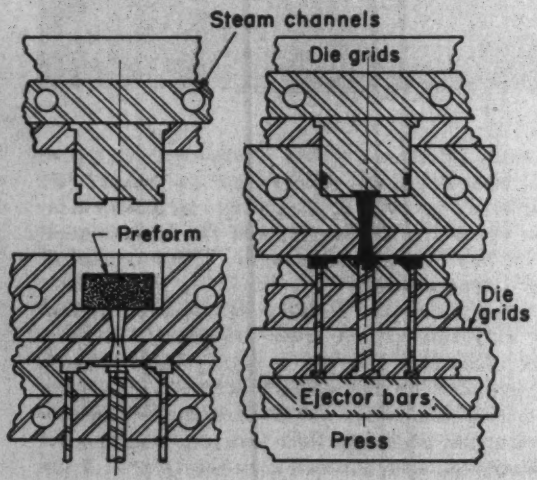


Fig. 4—Above—Typical arrangement of dies for compression molding

Fig. 5—Below—Die setup for transfer molding



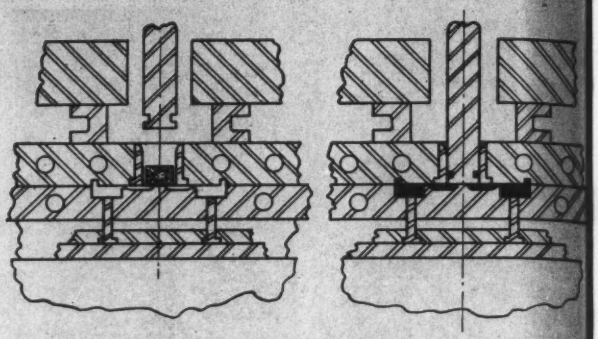


Fig. 6—Above—Duplex or plunger arrangement for transfer molding

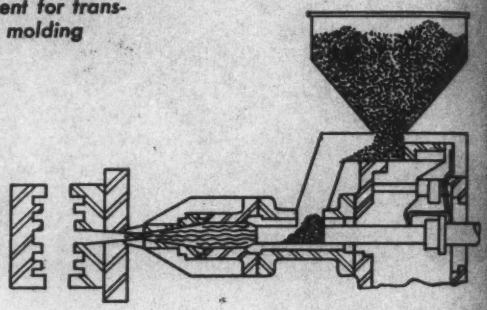
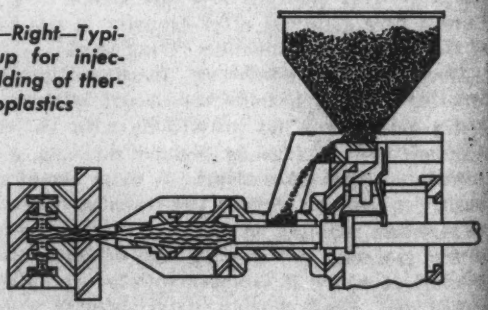


Fig. 7—Right—Typical setup for injection molding of thermoplastics



ods of forming plastics. Generally, thermoplastic materials are the only ones extruded.

Cold Molding: In the cold molding of parts, the powdered material is compressed cold to the desired shape. The compressed forms are then baked in ovens at a temperature of 225 to 500 F for a period of 12 to 14 hours depending upon size. Suitable plastics for cold molding are: (1) Nonrefractory types made with bitumen or phenolic resin base, and (2) refractory types made with inorganic binder compositions. Refractory materials receive in addition to the regular bake a special high-humidity baking treatment.

Laminated Molding: Laminated plastics are available in simple stock forms such as sheet, rod and tube which may be punched, sawed or machined as desired. However, where other forms are desired, laminated molding is utilized. In this method, layers of impregnated paper or cloth are located in a mold much like an ordinary compression mold, *Fig.* 8, subjected to pressure and curing temperature. Mold cycles are generally slow and may range from minutes to as much as several hours.

Where the parallel laminated structure is undesirable in parts for strength purposes, a variation of the laminate structure known as molded macerate is employed. Here, by shredding or chopping the cloth or paper, better flow is produced and a distorted, nonuniform, interlocked formation is obtained, *Fig.* 9. Although they show lower mechanical properties than straight laminates, the molded macerates have a more uniform overall strength. Like laminates, they are not suited to fast molding cycles.

In addition to high-pressure laminated molding is that of low-pressure laminated molding which utilizes primarily thermosetting resins capable of void-free polymerization at pressures under 500 psi. Plies of resin-coated or resin-impregnated wood, paper, cloth, or glass fiber are formed over a die by pressure applied through a flexible diaphragm, *Fig.* 10, with heat

to set the resin. Besides steam, other methods such as the vacuum bag, *Fig.* 11, and blanket are used to actuate the diaphragm.

Advantages of low-pressure laminated molding are found in the practically unlimited size of part in area, easy positioning of inserts or preformed shapes to provide assemblies or undercuts, low cost of production molds and equipment, thin sections of unusual strength and lightness, ease of forming hollow or complex shapes, and wide choice of material. Disadvantages lie in smooth, mold-finished surface on only one side of part and accuracy required in preliminary build-up of layers owing to poor flow characteristics of material.

One final method of producing molded laminates is by postforming technique Here the cured laminated standard sheet is heated to a temperature between 250 and 350 F, placed in the dies, formed, held until cool, and removed. Although glass fiber and paper-base materials have been formed with shallow draws, the various cloth base materials are preferable.

Molding Presses: A great variety of press equipment is available for molding plastics parts, ranging from simple manual types to large fully automatic machines. Compression and transfer molding presses, *Fig.* 12, range in capacity to 1800 tons and more and parts up to 20 pounds and greater are common. Television cabinets from 12 to 35 pounds and from 15 to 18 inches deep have been compression molded on large presses.

Injection molding machines, *Fig.* 13, in common usage generally range up to 9 ounces (acetate) capacity. However, there are in use today machines with capacities of 16, 22, 32 and 48 ounces, and at least one machine has been built for parts requiring up to 80-ounce capacity. The weight capacity of any machine is, of course, dependent upon the particular plastic. For instance, a 22-ounce acetate rated machine would be 16-ounce rated with polystyrene. Parts which exceed these figures are termed large-size injection molded parts.

Production Speeds: Ordinarily, injection molding presses can operate at speeds up to six cycles per minute the average being two to four cycles per minute. The average for compression molding is about six minutes per cycle. Thus, if a 2-cavity injection mold is operated at 4 cycles per minute, 48 pieces would be produced in the time required to complete one cycle in a compression mold. To equal this production, a 48-cavity compression mold would be necessary.

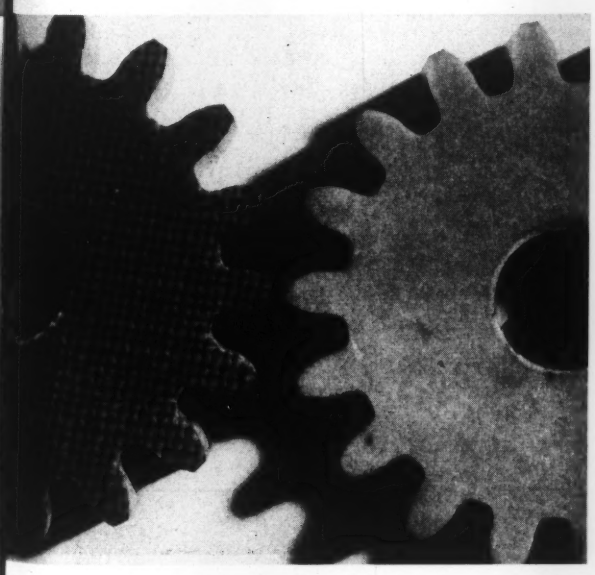
DESIGN FACTORS: The first overall consideration in selecting a method of molding, as well as that for practical molding in general, is accepted to be the piece design. Part detail design for molding thus becomes an outstandingly important consideration.

Wall Thickness: Of paramount importance in design of molded parts, wall thickness should be maintained as uniform as possible Abrupt changes should be avoided also. Uniform curing is dependent upon wall uniformity and ease in production as well as economy is promoted thereby. Whenever practicable, heavy sections should be cored out to attain a uniform wall. Uniformity of wall thickness in laminated molding is a design "must". Moderate changes in wall are possible but not desirable in the light of economy.

Minimum desirable wall thickness in compression molding is generally accepted as being 0.062-inch and increases with size. Walls as light as 0.031-inch are molded, however. Urea plastics may be designed with sections as light as 0.035-inch for relatively non-stressed parts but average wall is generally 0.050-inch and maximum wall, 0.125-inch.

For injection molded parts wall thickness should seldom be less than 0.050-inch unless travel of material is short and pressures high. Under any circumstances 0.015-inch is about minimum. Preferable wall ranges from 0.070 to 0.125-inch.

Draft: An important consideration in design is facility in ejection of parts from the mold after solidifying. Taper or draft is required on all sur-



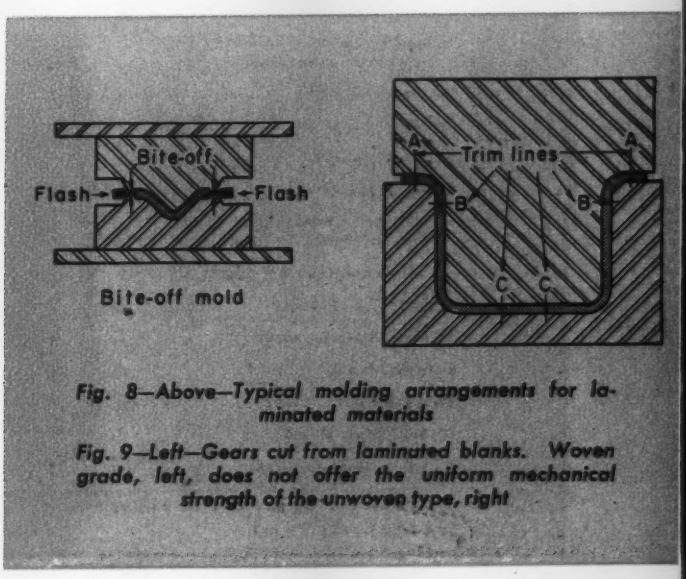


Fig. 8—Above—Typical molding arrangements for laminated materials

Fig. 9—Left—Gears cut from laminated blanks. Woven grade, left, does not offer the uniform mechanical strength of the unwoven type, right

faces normal to the parting plane of the mold. Interior walls, ribs, webs, recesses, and cavities should have a taper of at least one degree. Production costs increase sharply when taper is not included on outside wall design although it is possible to mold straight sides. Taper per side as low as ¼-degree can be used, but average draft runs from ½ to 5 degrees.

Generally, the draft with short walls can be figured at 0.005-inch per inch minimum but with longer lengths this can be decreased to as low as 0.001-inch per inch taper per side. Cold-molded items require a minimum draft of 3 to 5 degrees as do deep barriers and bosses.

Radii and Fillets: Generous fillets and radii on parts not only improve flow of the material in the mold but also add as much as 25 per cent to the strength. Fillets are preferred to sharp corners in all cases except at the parting line, *Fig.* 14. All parts should be designed with radii of 1/32-inch, minimum, and for cold-molded parts, 1/16-inch minimum. Stress concentration studies indicate a minimum fillet radius equal to one-fourth the wall thickness.

Owing to the character of laminated molding, generous corner radii at all points are essential. Sharp or square corners are difficult to produce and involve machining if necessary. Flowing lines materially aid the molding process.

Holes: Certain slenderness ratios have been established for molded work regarding the core pins necessary. In compression molding, blind holes of 1/16-inch diameter or less should not exceed their diameter in length. Larger blind holes are limited to a depth of twice their diameter. Deeper holes must be drilled. Limitations for intricate molded pieces are given in TABLE 1, with accompanying *Fig.* 15, and provide a reasonable factor of safety. Where holes are to be used for driving self-tapping screws, the blind hole should have a one degree taper per side. Depth of hole should accommodate at least 3/16-inch of screw.

Through holes, according to the foregoing ratios, can thus be made up to four times the diameter by two core pins which meet at the middle. One pin, however, should be at least 0.015 to 0.030-inch greater than the other to accommodate possible misalignment between mold halves. Where through-hole core pins can be supported in both mold halves, ratios up to five to one have been found practical.

Transfer and injection molding permit much greater

Table 2—Material Wall Thickness for Inserts†
(inches)

Material Molded	Insert Diameters									
	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	1 3/4	2
Phenolics:										
General-purpose	5/32	5/32	5/16	5/32	5/16	11/32	3/8	11/32	7/16	11/32
Medium-impact	5/32	5/32	5/32	11/32	5/32	7/16	11/32	3/8	11/32	7/16
High-impact	1/16	1/8	5/32	5/16	1/4	5/32	5/16	11/32	3/8	11/32
High-heat-resistant, general-purpose type	1/8	1/16	7/32	1/4	11/32	3/8	11/32	7/16	11/32	1/2
High-heat-resistant, impact type	5/32	5/32	5/32	11/32	5/32	5/16	11/32	3/8	11/32	7/16
Low-loss	5/32	7/32	1/4	5/32	3/8	11/32	7/16	11/32	1/2	11/32
Special for large inserts, flexible properties	5/32	7/32	1/8	5/32	7/32	1/4	9/32	5/16	11/32	3/8
Cellulose acetate	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	1 3/4	2
Cellulose acetate butyrate	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	1 3/4	2
Ethyl cellulose	1/16	5/32	1/8	5/32	5/16	7/32	1/4	9/32	5/16	11/32
Urea-formaldehyde	5/32	5/32	5/16	7/32	5/16	11/32	3/8	11/32	7/16	11/32
Melamine-formaldehyde Mineral filled ignition	5/32	5/32	5/16	7/32	5/16	11/32	3/8	11/32	7/16	11/32
Cellulose-filled electrical	1/8	5/16	7/32	5/16	11/32	3/8	11/32	7/16	11/32	1/2
Vinylidene chloride	5/32	1/8	5/16	5/16	7/32	1/4	1/4	5/32	5/16	11/32
Methyl methacrylate	5/32	1/8	5/16	1/4	3/8	1/8	3/8	1/2	1/2	1
Polystyrene	1/16	3/8	5/16	1/2	1 1/8	1 1/8	1 1/8	2 1/4	2 1/8	3
Polyethylene	1/16	5/32	1/8	5/32	5/16	7/32	1/4	9/32	5/16	11/32
Nylon Type FM-1	1/16	5/32	1/8	5/32	5/16	7/32	1/4	9/32	5/16	11/32
Vinyl chloride-acetate	5/32	1/8	5/16	1/4	3/8	1/8	3/8	1/2	1/2	1

† Table courtesy Society of the Plastics Industry, Inc.

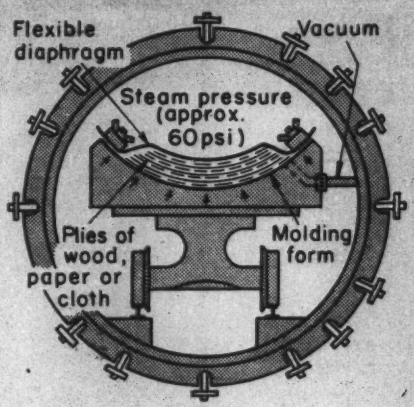
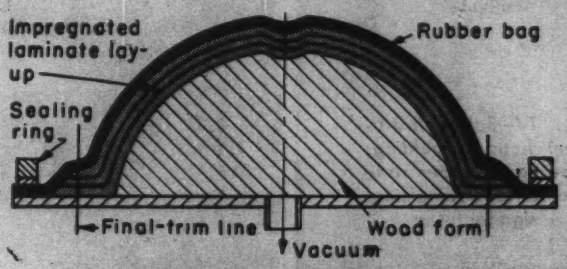


Fig. 10—Left—Low-pressure laminated molding in autoclave with steam

Fig. 11—Below—Vacuum-bag process for molding laminates



hole depths. Commonly, ratios of three or four to one and occasionally six to one can be used. With core pins supported in both mold halves, ratios up to twelve to one have been employed.

Poorly located holes may result in increased shrinkage and cracking. Holes under 3/32-inch diameter should be at least one diameter from the edge or wall of a part and never less than 1/16-inch from another hole. For larger holes lesser ratios are permissible as indicated in TABLE 1. In addition, holes should always be located parallel to the direction of mold movement to eliminate special molds and attachments. Likewise, holes at right angles are well to avoid if possible but, if needed, must be molded by transfer or injection. Square hole core pins tend to wear at the corners and where high accuracy is necessary special reinforced edges may be required on the core pins. Deep, narrow slots can often be made practical by including a heavier center shank portion for strengthening the core pin, *Fig.* 16.

Undercuts and Recesses: Wherever an undercut portion is used the problem of removal from the mold must be considered. Undercuts which necessitate split molds increase part cost considerably and, generally, internal undercuts are impractical. Internal recesses should be extended to the parting line to permit the part to be drawn out of the cavity or off the plunger. Internal and external recesses can sometimes be used to form a side hole in this manner, *Fig.* 17.

Bosses: Essential for mounting and assembly, bosses should be located whenever practicable in corners. Three bosses are preferable for mounting purposes. If four are necessary, a grinding operation is usually required to bring the top surfaces into planity. All mounting bosses should project 0.015-inch above all other projections in the same area.

High bosses which must be formed in the upper mold half should be avoided. High bosses have a tendency to trap gas and may be weak. Small bosses should not exceed two diameters in height. All large bosses should be hollowed to maintain wall uniformity. Wherever possible, especially on high bosses, a draft of 5 degrees on all sides is recommended along with generous fillets. Bosses are difficult to produce

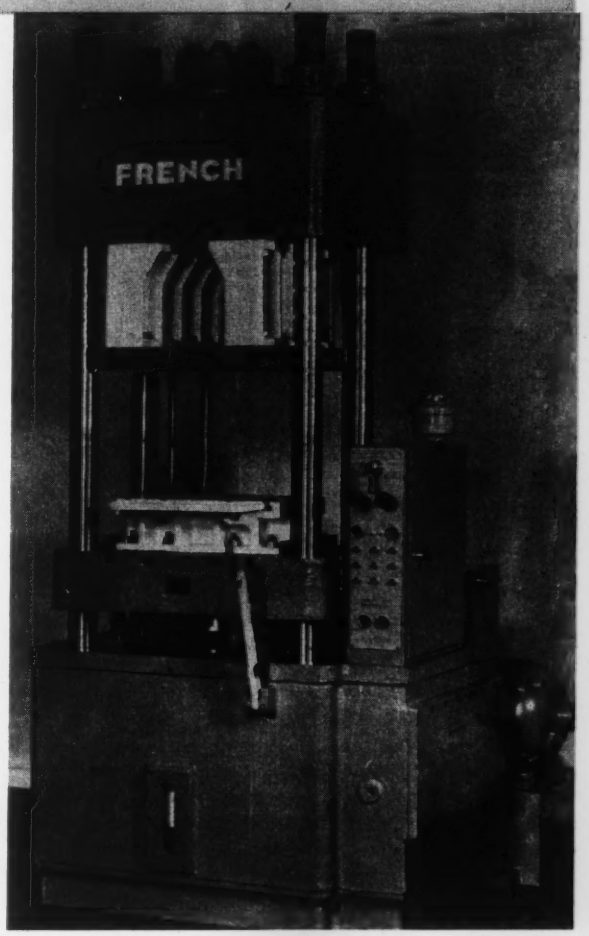


Fig. 12—Combination 100-ton transfer and compression molding press. Sizes range to 1000-ton capacity

in laminated molding and should be eliminated in favor of raised portions with uniform walls.

Ribs: Large, unsupported surfaces should be ribbed for strength and to resist warpage In addition to improving strength, ribs act as runners or feeders to assist material flow to isolated bosses, pads or projections. Ribs require generous draft and should

Fig. 13—Right—Injection molding machine for thermoplastics with capacity of two ounces per shot, six shots per minute

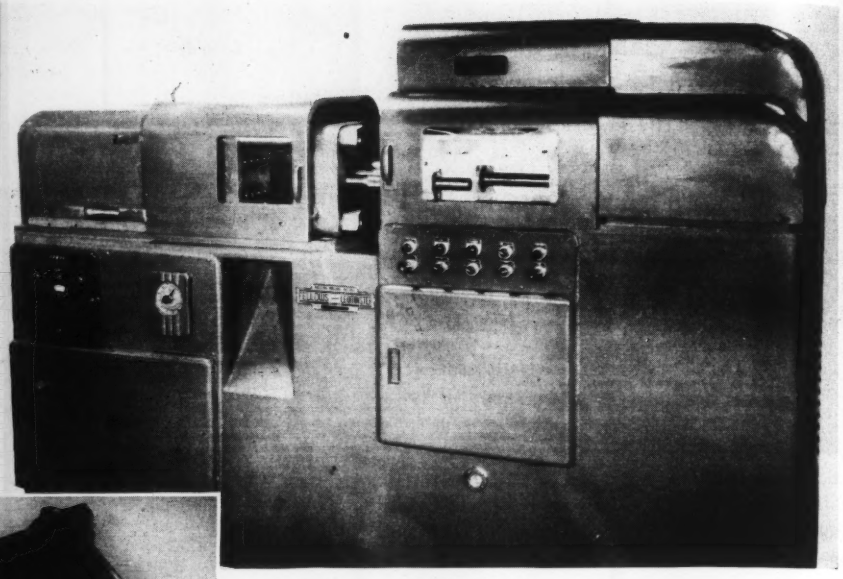
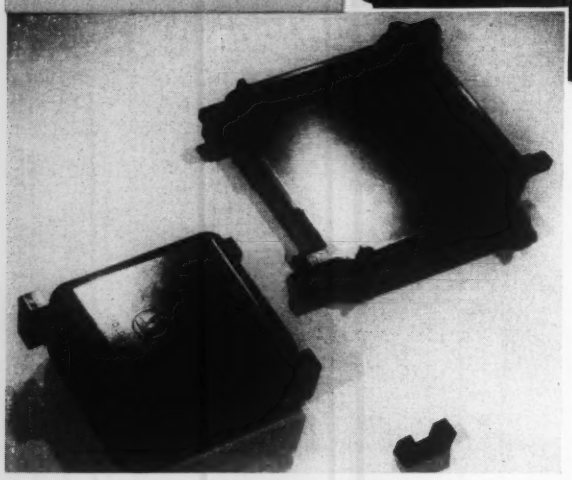


Fig. 14—Below—Instrument housing moldings showing generous radii and other typical design features



have at least 5 degrees taper per side, *Fig.* 18. Rib pattern over large areas should be staggered and consideration should be given the possibility of hollowing the ribs to maintain a uniform section. If rib sections are too heavy, shrink marks may appear opposite. The rib proportion in *Fig.* 18 will largely eliminate any possibility of shrink marks if the wall relationship of $2R$ is maintained.

Threads: As a rule, holes molded with threads are seldom satisfactory if the thread must engage metal, especially where frequent disassembly is necessary. Also, owing to shrinkage the pitch of molded threads of fair length will not fit standard metal threads but will match molded mating threads.

Generally, female threads over 5/16-inch diameter and under 32 pitch are molded. Tapping of threads over ¼-inch is impractical in phenolics. Small-diameter threads, especially under 3/16-inch, are usually more economical to mold as plain holes and tap. Tapped threads range from 68 to 75 per cent full thread and in small sizes the best possible fit is Class 2 with 68 per cent full thread. Tapped holes should have a molded-in counterbore or countersink to prevent chipping in assembly. Wall thickness of three diameters around tapped holes is recommended for adequate strength.

Internal threads may be molded integral and external threads may be molded in two sections with flash and parting lines removed by a sizing die after molding. Threads in blind holes with limited space or thin walls should be molded. Standard threads should always be specified. Threads should terminate abruptly in a shoulder of major diameter, feather edges are undesirable on mold parts. Likewise, threads should start at least 0.031-inch in from the face normal to the thread axis to avoid fragile feather edges, *Fig.* 19. Strongest possible molded threads result from use of flock-filled materials.

Inserts: If frequent disassembly is a thread requirement, the best design approach is to employ metal inserts. Threaded inserts, *Fig.* 20, require adequate thread length for assembly, sufficient strength to resist crushing in molding and proportions to assure suitable anchorage. Coarse diamond knurls for anchoring are recommended, although grooving or punching can be used, *Fig.* 21. Female through inserts should be avoided and means for preventing molding material from entering the threads is necessary with male or female pieces, *Fig.* 20.

Three types of male inserts shown in *Fig.* 22 exemplify good and poor design. For adequate anchorage, it is desirable to have an embedded length equal to two diameters and the coarse diamond knurl should terminate about 1/32-inch from the exposed shoulder to permit molding the insert in with about 0.005 to 0.010-inch projecting above the adjoining molded area. All inserts should be normal to the parting line of the mold for maximum economy.

Sufficient material is required around inserts to withstand the shrinkage on cooling without cracking. TABLE 2 indicates the SPI recommended wall thicknesses for various plastics with round inserts. In any case, walls under 3/32-inch are seldom recommended and should be avoided.

The majority of inserts are made of brass or steel, *Fig.* 23. Many types are standardized and available from stock. However, other materials are widely

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utilized for special designs such as porcelain, woven wire mesh, laminated phenolic materials, glass fiber, Mycalex, etc.

Where flanges are undesirable for holding or securing laminated molded parts, inserts can often be used. If high strength is desirable, T or U-bolt type inserts are preferred, *Fig.* 24.

Shrinkage: Molded parts are usually 0.000 to 0.020-inch per inch shorter than the mold after cooling. Some warpage also may occur. From the cold mold to the cold piece average shrinkage is approximately as follows:

Phenolic, wood flour filler	0.006 to 0.010 in./in.
Phenolic, fabric filler	0.003 to 0.007 in./in.
Phenolic, asbestos filler	0.002 to 0.006 in./in.
Urea	0.006 to 0.010 in./in.
Cellulose acetate	0.002 to 0.010 in./in.
Polystyrene	0.001 to 0.003 in./in.
Methyl methacrylate	0.002 to 0.006 in./in.

Identifications and Designs: For identity markings or designs with machined die cavities, raised letters should be employed, *Fig.* 25, and where dies are produced by hubbing, depressed letters should be utilized. Letters which project 0.003-inch above the surface are legible and about 0.010-inch is used as a desirable maximum value for lettering up to ⅛-inch. Where lettering or other markings are over 0.030-inch high, draft and fillets sould be used. Intricate designs which project about 0.003-inch can be produced by photographing and etching. Costs for various raised or depressed lettering compare as follows:

	Machined	Hubbed
Raised on molded surface	Low	High
Raised on depressed pad	Medium	High
Depressed on molded surface	High	Low
Photoengraved lettering	Low	Low

Sharp stamps will print or roll markings onto a surface without heat. Deep branding to 0.006 or 0.008-inch depth, however, is accomplished with heated dies.

Finishing: Letters to be filled with paint should be sharp edged from 0.005 to 0.030-inch wide, half as deep as wide, and with rounded bottom corners, *Fig.* 26. Where painting is necessary, adherence can be improved by sandblasting the part or the mold surface. Plastics can be coated with copper, chromium,

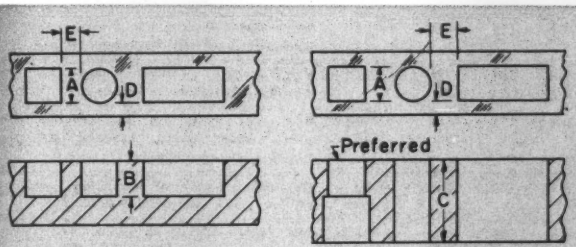


Fig. 15—Above—Design of molded holes. Values for various dimensions are shown in Table 1

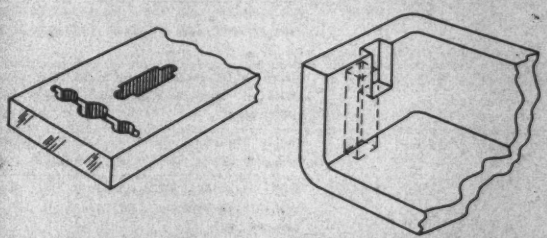


Fig. 16—Left, above—To strengthen deep, narrow-slot core pins, a round center portion is recommended

Fig. 17—Right, above—Both external and internal recesses should be extended to the parting line to simplify molding. In this design a side hole is produced

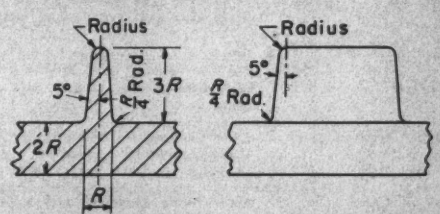


Fig. 18—Recommended proportions for ribs. Rib centerlines should not be closer than the rib base width dimension utilized in multiribbed designs

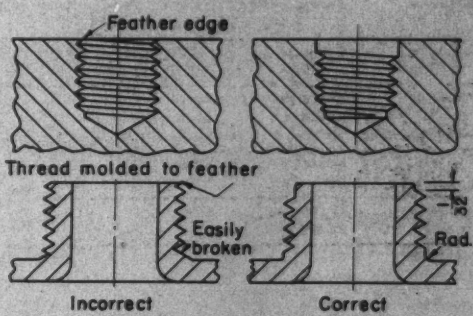


Fig. 19—Above—Feather edges on threads should be avoided in molding

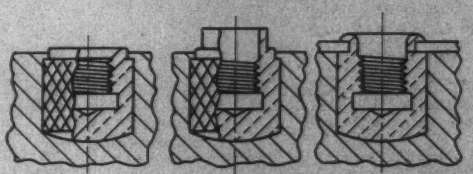


Fig. 20—Above—Typical female threaded inserts

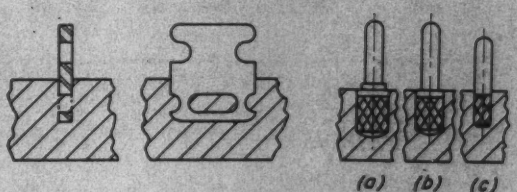


Fig. 21—Left, above—Stamped insert lug showing punched hole for anchorage

Fig. 22 Right, above—Male inserts with double seal (a) are best, single shoulder (b) provides reasonably adequate compound seal, shoulderless (c) requires added finishing operation at increased cost

Table 3—Applications and Physical Characteristics of Typical Plastics

Type	Filler	Colors	Tensile (psi)	Flexural (psi)	Water Abs. (% 48 hr)	Heat Res. (Cont. F)	Specific Gravity	Shrinkage (in./in.)	Applications to Machines
Phenolic	None	Amber	7000	12,500	0.02	248	1.27	0.012	Sterilizable parts, milking machine parts, jewel bearings
Phenolic	Woodflour	Most colors	7500	11,000	0.8	248	1.38	0.007	General-purpose, housings, etc.
Phenolic	Woodflour and graphite	Gun metal	6000	8000	0.8	248	1.39	0.007	Bearings, cams, slides, caster wheels, etc., reduced friction
Phenolic	Long fiber asbestos	Black, brown, natural	5000	10,000	0.06	300	1.90	0.001	Best for heat resistance, low moisture abs tion, low expansion, stability
Phenolic	Asbestos and graphite	Gun metal	5000	8000	0.06	300	1.82	0.003	Bearings, slides, gears, valves, cams, stability, resistance to wear
Phenolic	Fabric, short fiber	Natural, black, red, brown	6200	10,500	1.0	248	1.39	0.002	Medium impact, good flow for complex sec Agitators, housings, etc.
Phenolic	Fabric, medium fiber	Black, brown, red	6300	10,000	1.0	248	1.40	0.002	High impact for bulky sections
Phenolic	Chopped cord	Black	6200	11,000	1.4	248	1.35	0.003	Highest impact, not good for complex sec
Phenolic	Fabric and graphite	Gun metal	6000	8000	1.0	248	1.45	0.004	Cams, bearings, slides, gears, etc., for impact, low friction
Phenolic	Cotton flock & graphite	Gun metal	6000	9500	1.0	248	1.41	0.002	Bearings, cams, gears, slides, etc., for m impact, low friction
Urea	Cellulose	All	6300	11,000	1.5	170	1.48	0.008	Cabinets, housings, ignition parts
Melamine	Fabric	Natural, white, black and colors	6000	10,000	0.5	248	1.49	0.004	Good shock resistance. For nozzles, carbu housings, medical equipment parts
Melamine	Cellulose	All	8000	13,000	1.0	176	1.45	0.007	For inserts, aircraft electrical conne switches, instrument housings
Cold Mold	Nonrefractory asbestos	Black, brown	....	5500	3.0	370	2.00	0.010 to 0.025	Best cold mold for appearance. For w parts, small gears, handles, heat insula heavy-duty wheels, etc.
Cold Mold	Nonrefractory asbestos	Gray	....	5000	0.4	750	2.10	0.000 to 0.010	For parts requiring maximum heat resista switch parts, rheostat parts, etc.
Cold Mold	Refractory asbestos	Gray	....	4000	6.0	750	2.10	0.005 to 0.015	For parts subject to high-power arcing
Cellulose-acetate	.....	All	6000	9000	3.0	140	1.32	0.003	General-purpose for motor housings, etc.
Cellulose-acetate-butyrate	.....	All	5000	8000	1.5	140	1.22	0.003	General-purpose, for fuel lines, handles, ra refrigerator and vacuum sweeper parts
Ethyl cellulose	.....	All	6000	9500	1.4	150	1.14	0.004	Parts with good strength at low temperatu bobbins, camera and clock cases, dairy eq ment parts
Polystyrene	.....	All	5500	9000	0.05	158	1.06	0.002	Good stability, low moisture absorption, battery cases, housings, refrigerator parts
Vinylidene chloride	.....	Translucent, amber & opaque	6000	16,000	0.1	160	1.70	0.010	For chemical equipment parts, valve s textile machinery parts, fuel pump p pistons, etc.
Methyl Methacrylate	.....	All	8000	15,000	0.5	140	1.18	0.005	Transparency and stability excellent, for dows, dials, optical systems
Teflon	.....	Waxlike white or gray	4500	2000	0.00	400	2.10	....	Good flexibility at low temperatures, stab under heat, for gaskets, packings, diaphr and valve seats, etc., attacked only by a metals
Nylon	.....	Natural cream and seven colors	10,000	13,000	3.00	300	1.14	0.012	Toughness and stability, for gears, nonl cated bearings, valve seats, seals, packings
Alkyd (Plaskon)	Mineral	Brown	3500	9,000	0.26	400	2.2	0.004 to 0.007	For mechanical and electrical parts requ high heat resistance and good dimensional bility
Kel-F (M. W. Kellogg)	.....	Waxlike white or colors	9400	.....	0.00	400	2.1	....	Satisfactory for temperatures to –320 F, stability, extreme chemical resistance, for phragms, gaskets, seals, valve seats
Hard Rubber	.....	Black and red-brown	2000 to 9,700	2,818 to 12,500	0.04 to 0.30	300	1.21 to 1.95	0.020	Outstanding chemical and corrosion resista good electrical qualities, for gears, wate sistant parts, wheels, electrical parts, pu equipment parts

silver, gold, and other metals by electroplating or metal spraying.

Ejection: Ordinarily, parts must be removed after molding by means of positive ejection pins, *Fig.* 4. Such pins must bear on solid, firm portions which will not easily permit deformations. On a design, it is well to indicate where such pins can be utilized without affecting the finished part. As a rule, ejection pins leave a small indentation and an allowance either up or down of 0.015-inch should be permitted, *Fig.* 14. High ribs and barriers require knockout pins beneath and preferably a circular boss should be provided if practicable.

Parting Lines: Needless to say, molding is simplified and cost is held to the minimum by adhering to straight partings. Design of parts should be modified wherever possible to permit mold parting in one plane. This parting, for economy, should be so located that flash can be removed with a minimum of finishing. A bead or sharp edge simplifies removal.

Postforming: Laminates postformed hot preferably should have generous radii throughout. Typical forming radii vary from 3/32-inch for 1/16-inch sheet to 2½ inches for ⅜-inch sheet. Minimum radii for single and compound curvatures is generally set at two times the sheet thickness. Some drawing is possible and 1/16-inch sheet, for instance, can be drawn to a depth of 1½ inches for a 3-inch spherical cup. Deep drawn or complicated shapes having an ultimate elongation of 10 per cent lengthwise, 12 per cent crosswise, and 40 per cent diagonally are possible.

MATERIALS: Selection of the proper plastic for any particular machine application is important. Hasty selections without adequate consideration of all possible factors has resulted in numerous undesirable misapplications. Because it is impossible to obtain all the desirable superior properties in one material, the selection must be made on a compromise basis to obtain the best overall combination, *Fig.* 27. Not only are physical properties such as heat resistance and insulating characteristics highly important but also adaptability to economical molding or forming, *Fig.* 28. Parts which require special chemical resistance properties can be produced to precision requirements and at minimum cost, *Fig.* 29.

In TABLE 3, the various important properties of typical plastics materials are outlined along with some of their typical machine applications. Few successful machine applications of molded plastics can be made only on the basis of lower cost production or speed of output. The major factor influencing the use of molded plastics parts is the attainment of certain physical properties not available with other materials. Adaptability of design to molding follows in importance and attainment of minimum production cost, output speed, uniformity of product, elimination of assembly operations, etc., become highly valuable added features possible by thorough consideration of all the advantages and limitations of molding.

TOLERANCES: Several items must be considered in arriving at the practical tolerances for molded plastics parts: (1) Molding variations, (2) shrinkage, (3) warpage, and (4) aging.

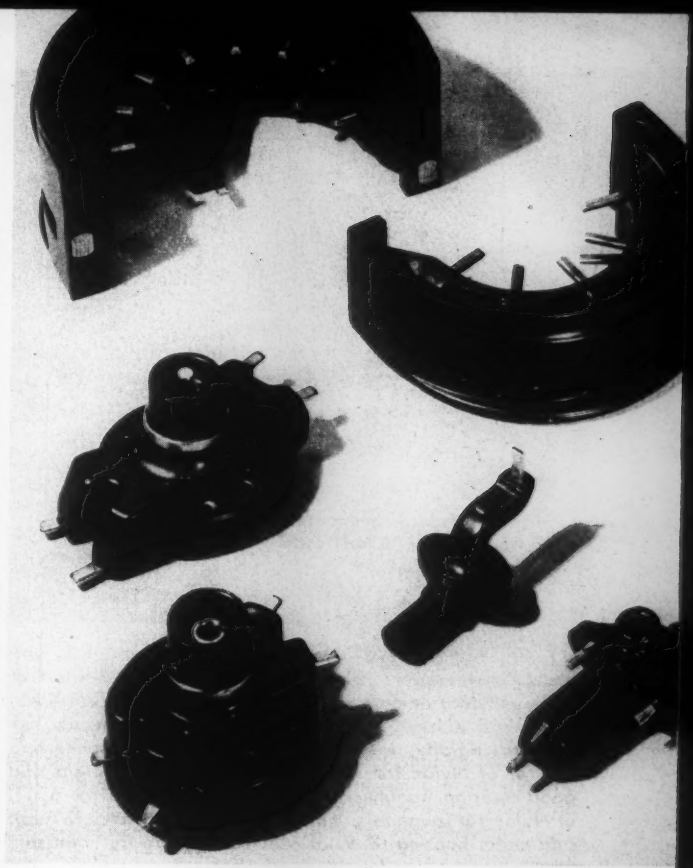


Fig. 23—Group of magneto parts showing wide possibilities for accurately placed insulated inserts. Parts are molded of thermosetting plastic hard rubber

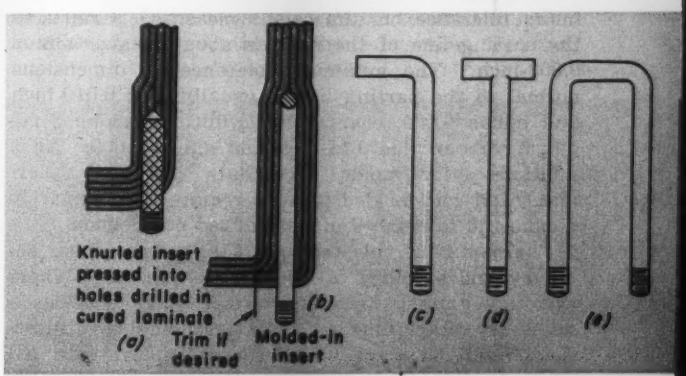


Fig. 24—Above—Knurled type inserts (a) are pressed into drilled holes after curing laminated molded part. Molded-in type at (b) are of typical designs shown

Fig. 25—Right—Molded phenolic face cam showing raised identification lettering

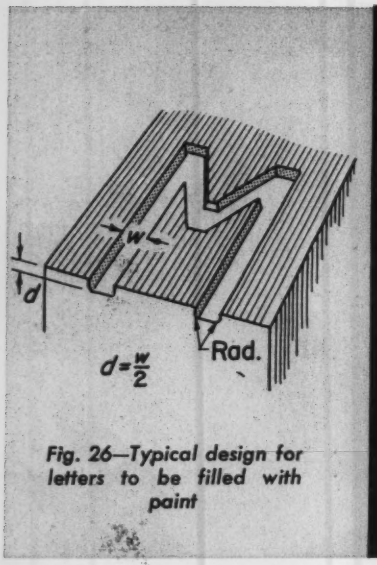


Fig. 26—Typical design for letters to be filled with paint

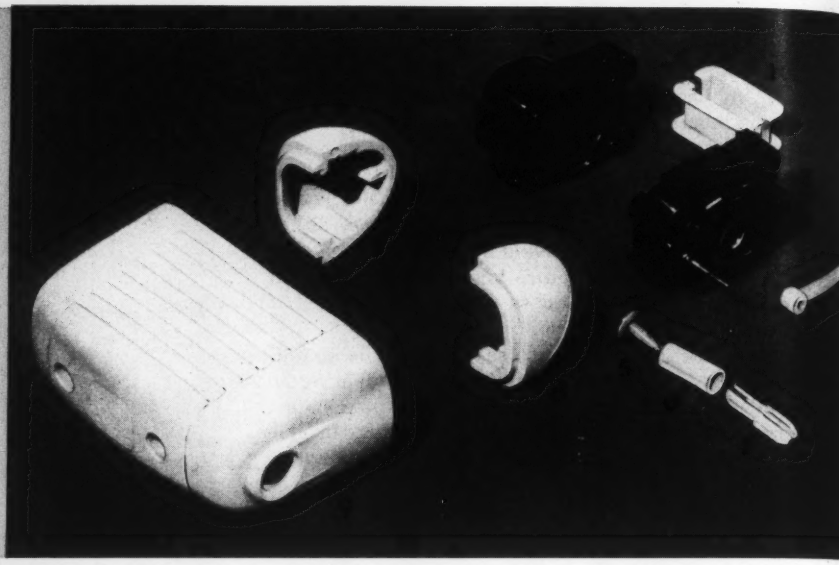


Fig. 27—Right, above—Group of molded parts for Sunbeam Shavemaster. Field coil bobbin (1) is molded of flame-resistant acetate for toughness and flame resistance; motor end blocks (2, 3) of improved impact phenolic for strength, rigidity, low weight and insulation; connecting rod (4) of Nylon for strength, toughness, low weight and good bearing qualities; motor connecting plugs (5, 6, 7,) of Nylon for toughness, moldability, and resistance to heat; and motor housing (8, 9) of cellulose acetate for color and underwriter's requirements

Molding Variations: As a general rule, the minimum tolerance on dimensions measured parallel to the parting line of the mold is about plus or minus 0.003-inch. The minimum tolerance on dimensions normal to the parting line is usually plus 0.010-inch and minus 0.000, coarse or rag-filled compounds requiring about plus 0.15-inch and minus 0.000. Also, multiple-cavity molds necessitate increased tolerances and cold-molded plastics require approximately double the tolerances of hot-molded compounds.

Thermosetting plastics provide the greatest accuracy and stability of dimensions, *Fig.* 30. Where accuracy greater than the normal range possible is necessary, machining or grinding should be utilized. An overall coverage of tolerances typical with the various molded plastics generally used is given in the Data Sheet on Page 135.

Shrinkage: Variation in section thickness creates nonuniform shrinkage. Thus, uniform sections result in uniform shrinkage and lower cooling stresses. Generally, shrinkage can be estimated within 0.002-inch per inch. Molding shrinkage for various compounds is given in TABLE 3.

Warpage: Some warpage is found upon removal of parts from the mold. This is especially true of cold-molded parts which are cured after removal from the dies. For most molded plastic parts, a good working tolerance for warpage is about 0.003-inch per inch, plus or minus, from planity.

Aging: Dimensional changes on aging varies among the different plastics and, under severe operating conditions, on occasion may approach the value of mold shrinkage. Plastics compare in general as follows in this respect, number one being best:

Phenolic, heat-resistant	1
Phenolic, low loss	2
Polystyrene	3
Phenolic, general-purpose	4
Phenolic, acid and alkali	5
Phenolic, impact	6
Urea	7
Cellulose acetate	8
Cellulose acetate butyrate	8

Finish: The surface quality of molded parts depends largely upon the mold surface utilized. Standards for plastics have, as yet, not been established for guidance in setting design specifications At least one manufacturer has set up a series of surface standards for appearance only and these are as follows:

Fig. 28—Fourteen molded Nylon parts are employed in this Fairchild rate gyro. Toughness over a wide temperature range, resistance to fungus, and high degree of moldability and economy influenced its selection

As-Molded Finish

1. Highly polished gloss
2. Semigloss, commercial
3. Low-cost for experimental parts
4. Fine-grain parallel lines
5. Modification of 4 with deeper markings
6. Satin, from abrasive air blast of molds.

Mechanically Applied Finish

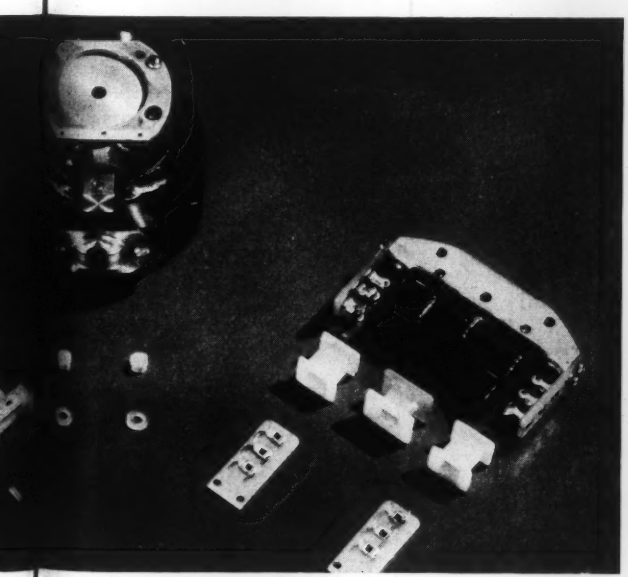
1. Dull, grained parallel lines
2. High polish, glossy
3. Low-cost buff, fair gloss.

Often, finish is important and glare from glossy surfaces is undesirable. Too, some standard is desirable to assure duplication of finish in some cases and to simplify the specification of surface finish.

Better finish as well as efficient flash removal is obtained by Wheelabrating plastics parts with a blast of nonabrasive pellets such as crushed apricot pits or crushed walnut shells. These materials do an excellent job of flash removal without marking the molded surfaces, eliminating approximately 95 per cent of all hand finishing operations.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:

American Hard Rubber Co. (*Fig.* 23) . . New York, N. Y.
Amos Molded Plastics Div. (*Fig.* 7) . . . Edinburgh, Ind.
Bakelite Corp. (*Figs.* 1 and 3) . . . . . New York, N. Y.
Chicago Molded Products Corp. (*Fig.* 27) . . Chicago, Ill.
E. I. du Pont de Nemours & Co. (*Fig.* 28) . . . . . Wilmington, Dela.
Durez Plastics & Chemicals Inc. (*Figs.* 4, 5, 6, 29, and 30) . . . . . North Tonawanda, N. Y.
Eclipse Molded Products Co. . . . . Milwaukee, Wis.
Fellows Gear Shaper Co. (*Fig.* 13) . . . . . Springfield, Vt.
Formica Co. (*Figs.* 2 and 9) . . . . . Cincinnati, O.
French Oil Machinery Co. (*Fig.* 12) . . . . . Piqua, O.
General Electric Co. (*Figs.* 8, 10, 15, 16, 17, 18, 19, 20, 21, 22, 25, and 26) . . . . . Pittsfield, Mass.
M. W. Kellogg Co. . . . . Jersey City, N. J.
Laminated Plastics, Inc. (*Figs.* 11 and 24) Cleveland, O.
Plaskon Div., Libbey-Owens-Ford Glass Co. . . Toledo, O.
Richardson Co. . . . . Melrose Park, Ill.
Westinghouse Electric Co. (*Fig.* 14) . . . . Pittsburgh, Pa.



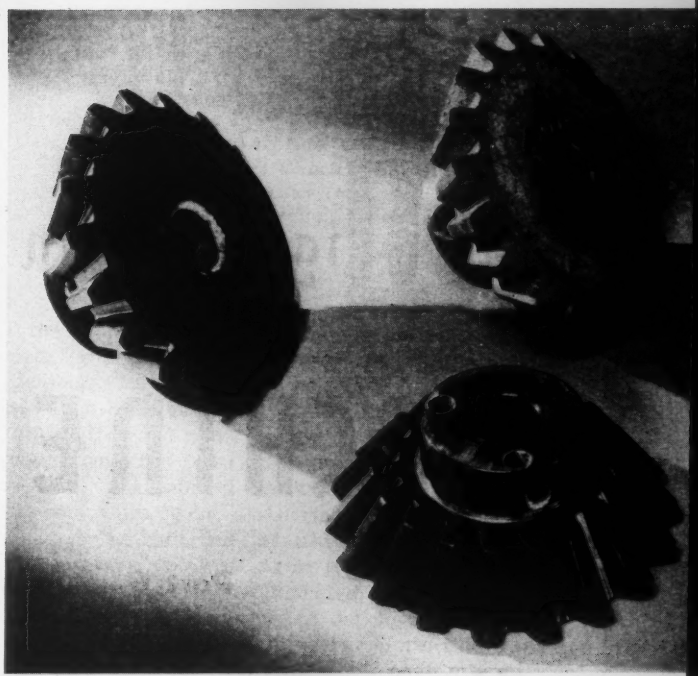
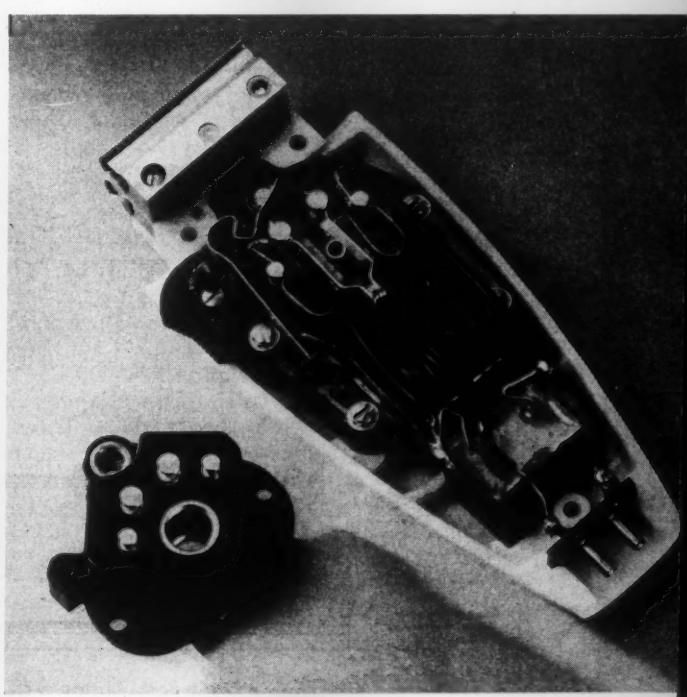


Fig. 29—Above—Three-inch Durez bevel gear molded complete for continuous rayon spinning machine drive. Insert, hobbing operation and machining of teeth and insert of laminated previous gear, top right, was eliminated

Fig. 30—Below—Motor bearing support for Schick electric shaver molded of Durez with complex inserts in eight-cavity molds. Large hole inserts require line reaming before inserting oilless bearings. Close dimensional control is achieved, total tolerance on the U-shape jaw opening is only 0.012-inch



Highlights in the History of

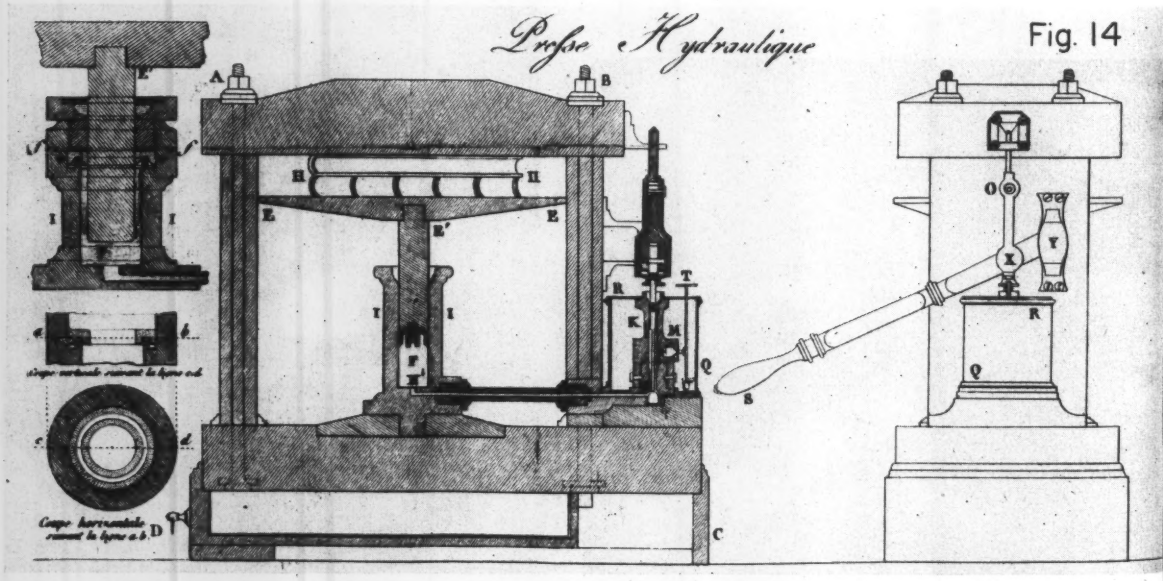
MACHINE HYDRAULIC

Part 6 — Pumps, Motors and Valves

BY 1800 much progress had been made in the development of reliable pumping machinery and the way was being prepared for the onward progress of other hydraulic machines.

This extract from a paper published in 1880 discloses a degree of reliability of which a modern hydraulic manufacturer would be proud:

> Upon the advent of Watt's steam engine, and owing to the sensation it created in the mechanical world, the peculiar advantages of water-pressure engines were lost sight of for some time, but in 1803 Trevethick erected one at the Alport Mines, Derbyshire, where it was in use for many years . . . another water-pressure engine . . . was fixed in 1842, and was the largest of the kind up to that time. Some idea of its magnitude may be formed when we state that the cylinder was 50 inches in diameter and the length of stroke 10 feet, upwards of 4000 gallons of water being raised to the height of 136 feet every minute. Among the numerous advantages of hydraulic machinery is the small amount of attention it requires compared with other machinery. On one occasion in answer to an in-



quiry as to the performance of this engine, after it had worked for six years without intermission, the answer was that it had been going constantly for the last seventeen weeks, but *nobody had seen it* during the time.

Inventor of the hydraulic press was Joseph Bramah who took out his patent in 1795. This press was not, however, entirely original, its conception having been anticipated by Pascal many years earlier, but Bramah was responsible for its practicable realization. The early units consisted of a plunger hand pump, a ram, and a cock to release the pressure. *Fig.* 14 is a reproduction of an early design. It will be noted that the release cock is in reality the suction valve of the hand pump; when it is opened, the press can be released by pulling the pump handle fully down, this action opening the pump delivery valve and releasing the oil back through the pump to the tank. The first presses had ordinary cup leathers but the "automatic" or U-packing was soon invented by Maudslay who was one of Bramah's assistants. This is shown on the left of the illustration, which is taken from a well-known French text book of the period (Hachette, 1819). Some references claim that the inventor of the U-packing was in fact Benjamin Hicks who improved and manufactured hydraulic presses in 1810-20. Maudslay (also known for his invention of the lathe slide rest) was probably the true inventor.

It would seem that after Bramah it was William Armstrong (later Sir William Armstrong, founder

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of the Company now known as Armstrong Whitworth) who began in 1836-40 to develop hydraulic machinery for purposes other than presses. In 1846-9 he built several hydraulic cranes complete with control and relief valves in Newcastle-upon-Tyne, where the town water supply was of good pressure. He installed hydraulic cranes, and dock gate and sluice gear, at Grimsby in 1849; in the same year he built and installed a two-cylinder hydraulic rotary motor or engine for a mine. A year later he is stated to have invented and applied the first hydraulic accumulator. A development of the air vessel of Ctesibius 2000 years before, this was at first of the pneumatic type, without piston, although a rubber diaphragm was unsuccessfully experimented with; air loss could not be prevented and later a dead weight creating a maximum pressure of 600 psi (this being six or seven times greater than that used previously) was successfully introduced. The substitution of steam pressure for the dead weight is due to A. B. Brown some time later.

A little later Armstrong added an automatic mechanism connecting the accumulator dead weight with the steam valve of the steam engine which operated the hydraulic pump, so that the rise and fall of the accumulator stopped and started the hydraulic pump automatically. Here was the origin of the automatic unloading and switching arrangements used on many modern hydraulic and pneumatic installations.

Early Recognition of Differential Principle

A little later was devised the "differential area" system, much appreciated by hydraulic specialists today but still not very well known. Here the annular area of the jack or cylinder is connected to the pump to close the unit; to extend it, the pressure is applied either to the full piston area at the same time as the annular area (so that the pressure acts effectively on the piston rod area), or to the full area alone, the annular volume being exhausted. This system gives two areas (and consequently forces) for extension; it was originally applied to hydraulically operated cranes, to economize in water consumption at light loads.

In 1874 Adams, author of the paper quoted above and an assistant of Armstrong, devised what

(*Concluded on Page* 178)

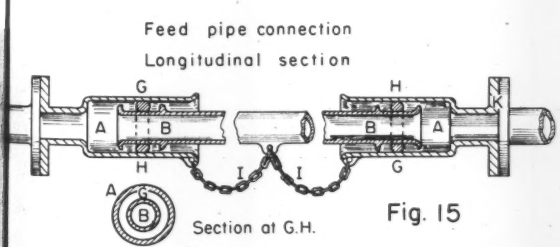
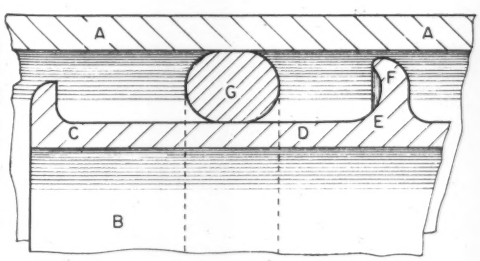


Fig. 15



Section at G.

Hardfacing

. . . in original design provides greatly increased capacity and service life

By F. W. Weigel
Works Manager
The V. D. Anderson Co.
Cleveland, Ohio

Fig. 1—Hardfacing a worm shaft for a large mechanical screw press. Effective life of part is increased 300 per cent over that of hardened steel

FROM the experimental stage, hardfacing technique for protecting parts against wear has developed until, at the present time, almost any wearing part, *Fig.* 1, of a machine can be provided with a protective coating of hardfacing. Necessity for prolonging the life of wearing parts has led to refinements in the hardfacing process and in the design of parts for such application.

Continuous mechanical screw presses used in the vegetable oil industry provide an excellent example of the advantages obtained with hardfacing design. To indicate the extreme service to which these presses, known as expellers, are subjected while extracting oil from cottonseed, soybeans, flaxseed, packing house offal, etc., imagine, if you will, a 30,000-pound meat grinder driven by a 70-horsepower motor. Its barrel is lined with steel bars arranged parallel with the worm shaft. These bars are separated by hard spring-steel spacers to provide openings for the escape of the oil. Solid matter is extruded under pressure through a variable annular opening around the shaft at the discharge end of the barrel.

Pressures developed inside the barrel amount to several tons per square inch and the temperature varies from 210 to 270 F. The worm flights for compressing the material and for advancing it along the barrel are subjected to severe wear. Other parts which come in contact with the material—which may be abrasive in itself or contain abrasive foreign matter—are also seriously affected. In addition to the problem of abrasion there is also one of corrosion. The materials usually contain vegetable or animal acids which, at elevated temperatures and pressures, attack even the best alloy steels.

As long as low capacities and a relatively high residual oil in the pressed material were acceptable, the problem of wear and tear on parts was not serious. But with the expansion of the vegetable oil industry, greater and greater capacities per unit were demanded and the standard of performance was improved until the power required per press increased from the original 15 hp to 70, 80 and even 100 hp. The inevitable result was that the life of hardened-steel parts was reduced in proportion to the amount of power applied and the tonnage handled per unit.

Experimentation was begun with hardfacing the most seriously affected parts, namely, the pressing worms illustrated in *Fig.* 2. Later the spacing collars and the feed worm were added, *Fig.* 2. This feed worm was the largest part attempted and was considered an accomplishment. The worms were built

up rough and then finish ground. They may be built up of solid hardfacing materials as in the pressing worm or over a steel core as is indicated in the feed worm. In quick succession the choke jaw, bushing, ring, and barrel bar shown in *Fig.* 3 were redesigned.

As satisfactory methods were developed and a sufficient number of hardfaced parts placed in service, the practicability from a manufacturing standpoint and the economic advantages from the customer's standpoint were demonstrated. In spite of the increased cost of hardfaced parts, the customer found he could well afford the greater initial outlay since the effective life of the parts was, in most cases, increased more than 300 per cent above that of the same parts when made of hardened steel. Also, he had an additional gain in production since the down time for repairs was decreased in proportion.

It should be noted that the worm shaft parts were originally designed in the form of short sleeves and collars keyed to the main shaft to produce the assembly illustrated in *Fig.* 2. The next design incorporated all of these parts, with the exception of the feed worm, into one long sleeve as illustrated in *Fig.* 4. Later the three component parts in the assembly in *Fig.* 2 were combined to make the integral main worm shaft as shown in *Fig.* 5. Approximately 50 pounds of hardfacing rod is applied to a heat-treated blank of alloy steel, *Fig.* 1, to produce this piece.

Hardfacing materials by their very nature being hard and usually brittle have a limited resistance to shock. When the height of a worm flight approaches or exceeds its width, the practice is to build up the hardfaced flight over a steel core to give the flight more structural strength. Foreign matter in the form of stones and tramp iron frequently get into an expeller. The worm flight, therefore, must be strong enough to reduce these materials to pieces sufficiently small to pass through the expeller barrel.

The same factors which govern depth of case hardening in conventional heat treating control the thickness of hardfacing. If a part is useless when 0.025-inch of the surface is worn away, it is a waste of effort and material to apply more than that amount of effective overlay. Also, if various portions of the same part are subject to different degrees of wear, the areas subjected to the severest conditions have the heaviest deposit. In *Fig.* 2, the hub of the worm with 1/16-inch thickness of hardfacing as compared with 7/16-inch on the worm flight is an example.

Hardfacing may taper off or may be recessed depending upon requirements of the job. The transition area between the parent metal and the hardfacing is actually an alloy of the two so there is no danger of flaking off of very thin deposits.

In *Fig.* 6 are shown many hardfaced parts. Each is finish ground all over. In general, grinding stock varies from 1/32 to 1/16-inch. Thickness is controlled by the nature of the materials being applied and to a great extent by the individual skill of the welder. Some materials are more free flowing than others and a smoother deposit can be obtained. An experienced and skillful welder will naturally produce a smoother job than an inexperienced one.

Another product utilizing hardfacing is a flaking

Fig. 2—Details of hardfacing for pressing worm, spacing collars and feed worm. Relationship of parts are shown in the assembly drawing of the shaft

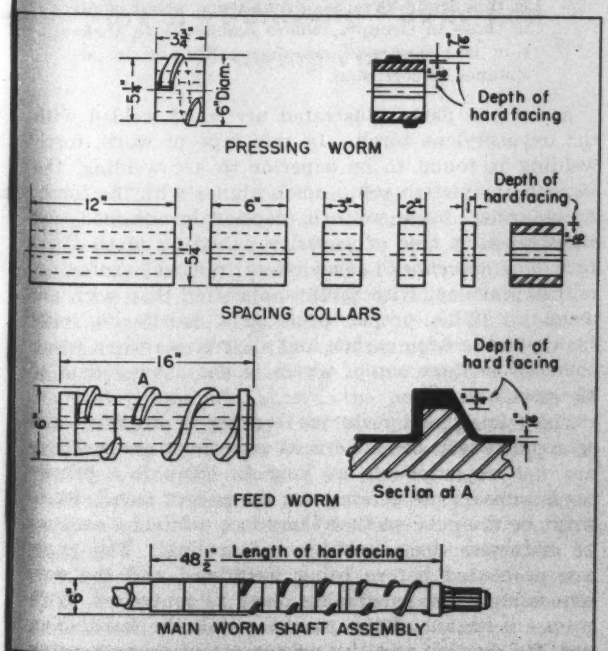
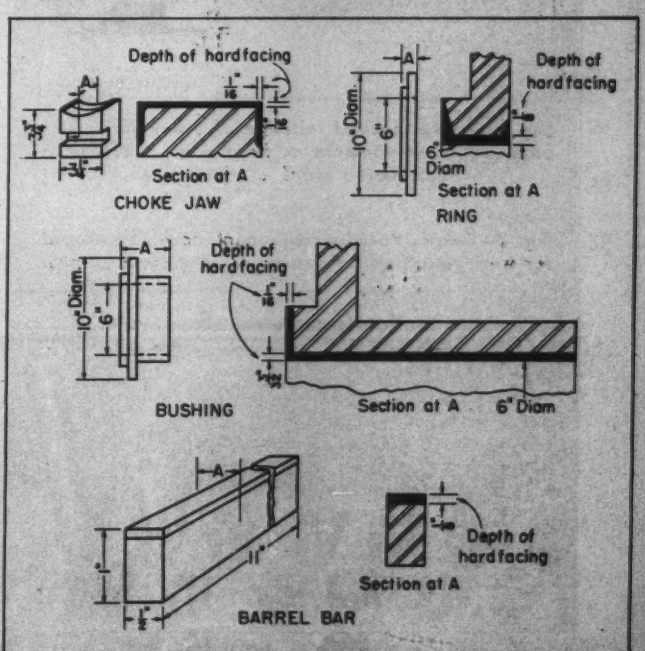


Fig. 3—Drawings of choke jaw, bushing, ring and barrel bar showing hardfaced surfaces and depth of overlay for each service requirement



roll. It is a one-piece forging weighing more than 5000 pounds. The roll surface, 24 feet in diameter and 40 feet in length, is covered with a deposit having a hardness of 52 Rockwell C. This roll is one of a pair which is used for flaking materials preparatory to extraction by a solvent extraction process and sometimes abrasive substances are present in the materials being processed. The hardfacing is applied by the continuous submerged-arc process. When the proper rod is selected the submerged arc lays down a deposit which is remarkably free from crazing, porosity or other surface defects. The selection of hardfacing rods for this use, however, is limited to those types which can be drawn into wire or tube form for use with the automatic welding head.

An additional advantage to the customer in using hardfaced parts is the fact that, in many cases, worn parts may be returned to the factory for resurfacing. This is not generally true for hardened-steel parts.

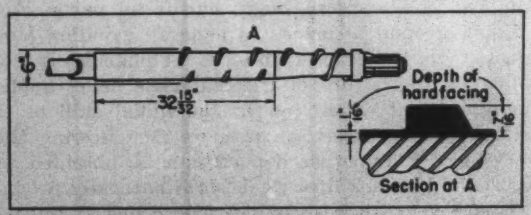


Fig. 4—Above—Redesign of worm shaft incorporates pressing worm and collars into one sleeve

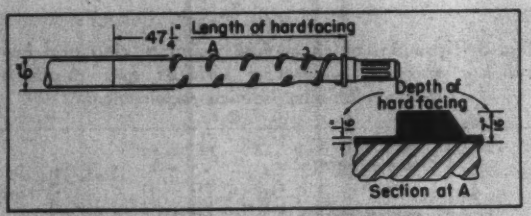
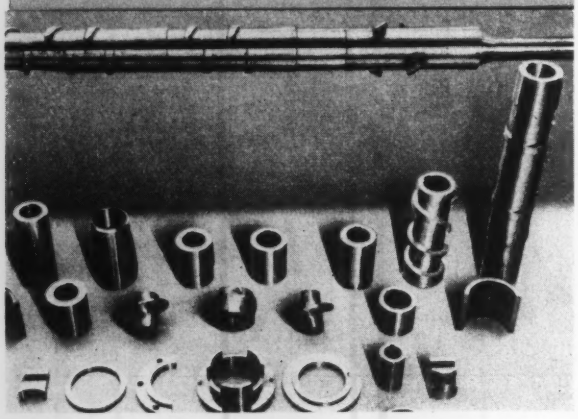


Fig. 5—Above—Second redesign of worm shaft combines all three components hardfaced direct on a heat-treated blank of alloy steel

Fig. 6—Below—Various component parts, hardfaced for wear resistance. Parts are finish ground all over



The selection of steel for the manufacture of hardfaced parts is usually different from that which would be used in making the same part to be hardened.

Types of Welding Rods

Welding rods used for hardfacing fall into three general material classifications:

1. Cobalt-base alloy rods. Alloys of cobalt, chromium and tungsten have the widest range of application and are generally used where the three factors of corrosion resistance, wear resistance and low coefficient of friction are all of importance
2. Composite or tube rods. Consisting of hard abrasion-resistant particles suspended in a softer matrix, such as iron or nickel, rods of this type are used where the corrosion or erosion are such that the soft matrix is not removed from around the hard particles. In cases where such action does occur these rods are not used. The nickel-base rods in this group have the distinct advantage that the temperature of application is several hundred degrees below that of other types. This reduces shrinkage and distortion and the surface is usually smoother and more uniform in appearance. This in turn reduces the time required for finish grinding
3. Iron-base alloy rods. These are alloys with iron of usually three or more of the following elements: Cobalt, tungsten, chromium, nickel, vanadium, molybdenum, silicon, zirconium, manganese and carbon. The possible combinations in this group are, of course, too numerous to mention and the grades of welding rod offered commercially run into the hundreds. In general, the resistance to abrasion and corrosion of this group of rods varies with the amount of abrasion-resistant and corrosion-resistant alloys present. Certain rods in this group have been found just about equal to those in Group 1, where resistance to abrasion is concerned and approach them in resistance to corrosion.

All of the parts illustrated are hand welded with the oxyacetylene torch. In this type of work, torch welding is found to be superior to arc welding, the rate of application being much higher with the torch. A smoother, more uniform deposit is obtained and the deposit is free of porosity. Crazing of the surface, which occurs to some extent in most hardfacing, is less prevalent with torch application than with arc welding. With proper procedures hardfacing may be applied to high carbon and alloy steels when using the oxyacetylene torch, which is not always true of the open arc.

Hardfacing materials are lacking in ductility and as a part cools, surface cracks sometimes occur. These are not objectionable as long as there is a proper bond between the overlay and the parent metal. Parts must be designed so that there is a minimum amount of distortion upon heating and cooling. The parts are preheated before being hardfaced and the rate of cooling after hardfacing must be controlled. With proper selection of the parent metal, the hardfacing rod for the job and the proper attention to heating and cooling rate, cracking is held to a minimum.

Charts Simplify Calculations

By Tyler G. Hicks
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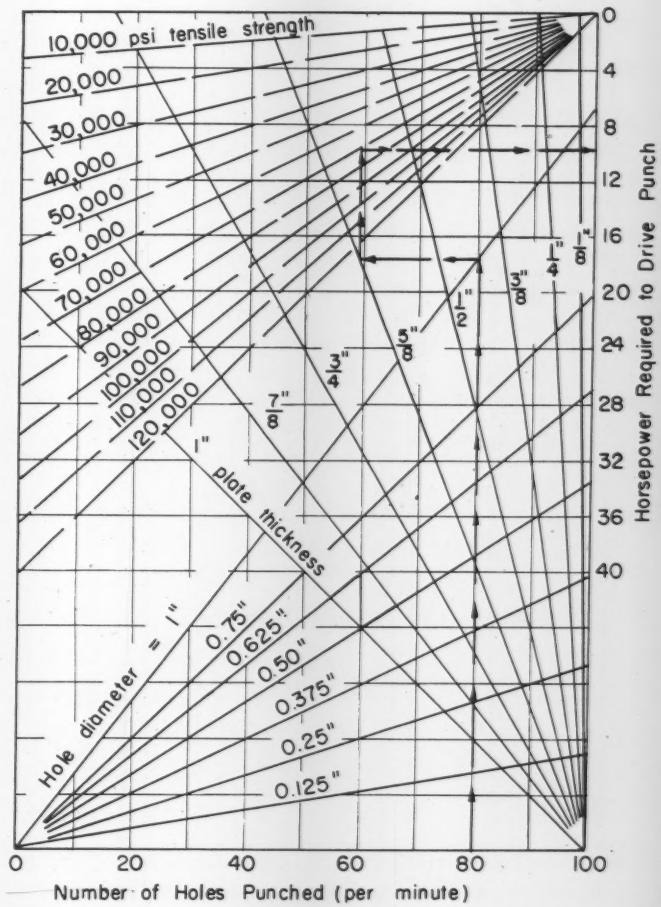
Part 2—Punching Power and Drawing Forces

CONTINUING from the first design chart on bending which was presented in the March issue of MACHINE DESIGN, this part presents charts on drawing pressures and punching forces.

PUNCHING: Shown on this page is an intersection chart for determining the power required to punch various metals. With the hole diameter, plate thickness, material tensile strength, and number of holes punched per minute known, the power necessary to drive a punch press can be determined directly. Alternatively, the chart may be entered for any one specific value knowing the others.

Example: Determine the horsepower required to punch eighty 1-inch diameter holes per minute in a 0.625-inch thick plate with a tensile strength of 70,000 psi.

Enter the bottom of the chart at 80 holes per minute and project vertically to the 1-inch diameter curve. From here project horizontally to the 0.625-inch thickness curve and then vertically to the 70,000 psi



tensile strength curve. At the right read 9.65 horsepower.

Chart is based on the formula

$$P = 0.2645\ t^2\ D\ N$$

where tensile strength is 60,000 psi, and

P = Horsepower required to drive punch
t = Plate thickness, inches
D = Diameter of punched hole, inches
N = Number of holes punched per minute.

Other tensile values are plotted in proportion.

DRAWING: The chart on this page is suitable for determining the force required for drawing shells, tubes, and similar shapes from all usual metals. In order to use this chart the yield tensile strength, length of drawing edge, and type of blankholder must be known.

Example: A 4.76-inch diameter shell is to be drawn from a ⅛-inch thick plate which has a yield stress of 110,000 psi. Determine the drawing force required if a blankholder is used in the operation.

Total length of drawing edge for a 4.76-inch diameter shell is its circumference, or 4.76 (3.1416) = 15 inches. Enter the chart at a drawing edge length of 15 inches and project horizontally to the ⅛-inch plate thickness curve. From here project vertically to the 110,000 psi yield stress curve and then horizontally to a blankholder area of $(4.76)^2(3.1416/4) = 17.9$ sq in. At the bottom read the drawing force as 106 tons. If a blankholder were not used, projection to the zero area curve would give the required drawing pressure.

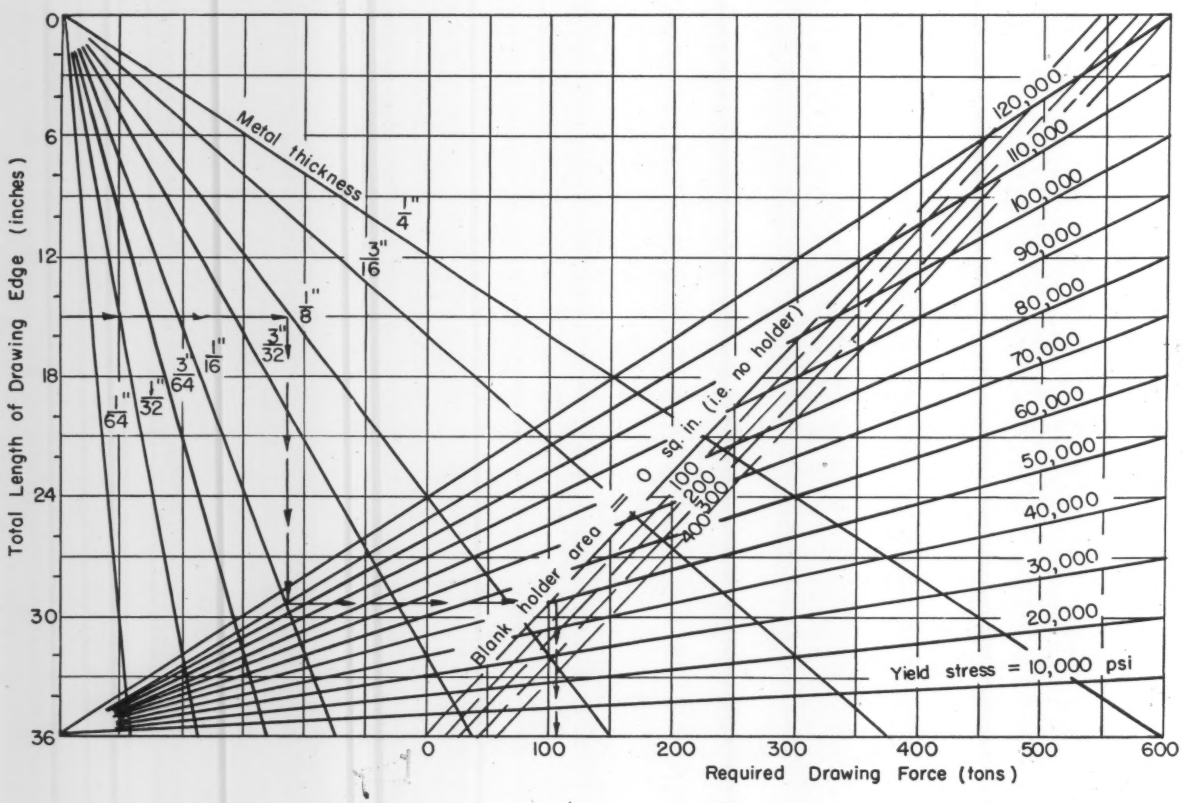
This chart is suitable for any shape draw provided that the proper edge length is used when entering. If any value, such as drawing edge, metal thickness, yield strength, or blank holder area is beyond the limits of the chart, divide all values by a suitable number and solve in the same manner. Multiply the result by the selected number to obtain the actual drawing force required.

Chart is based on

$$F_d = L\ t\ S + P_b\ A$$

where

F_d = Drawing force, tons
L = Drawing edge length, inches
t = Metal thickness, inches
S = Yield point stress, tons per sq in.
P_b = Blank holding pressure, here assumed to be 300 psi or 0.15 tons per sq in. (values range from 150 to 300 psi; chart is on the safe side)
A = Blank holder area, sq in.



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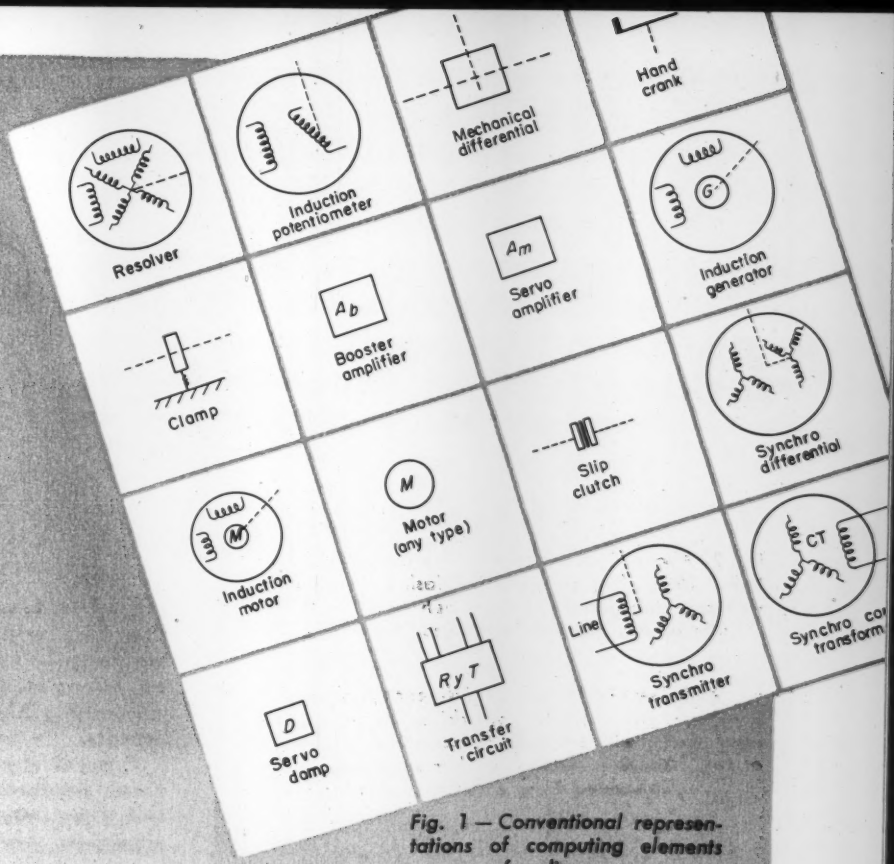


Fig. 1 — Conventional representations of computing elements for diagrams

Employing Computer Components in Machine Control

Part 1–Adding and Subtracting

FOR many years servomechanisms of one kind or another have been used in controls for various processes and devices. These mechanisms have received particular attention in connection with the control of gunfire and bombs, but the designer of machines has become more and more conscious of their possibilities in industry.

The machine designer is also aware of the existence of computers for the calculation of lead angles, level and cross level, and all the other quantities involved in shooting a fast airplane from a moving and heaving ship in a high wind, but he probably does not realize that such computers can be assembled from completely standardized components, and that the computations are the same in their elements as those which he must make every day. The complete calculation of fire control problems is naturally involved, because of the large number of vari-

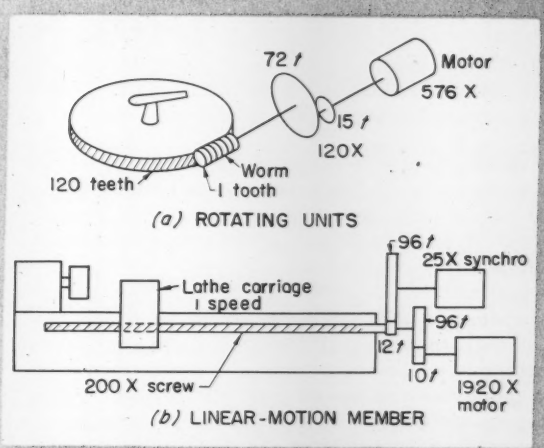


Fig. 2—Method of indicating relative speeds for rotary or translated motions for gun turret and lathe carriage

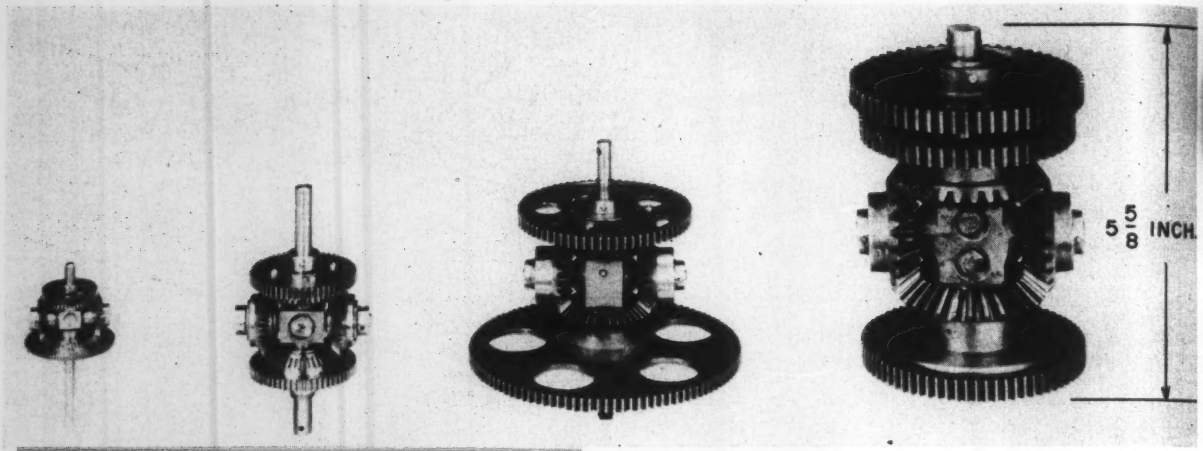
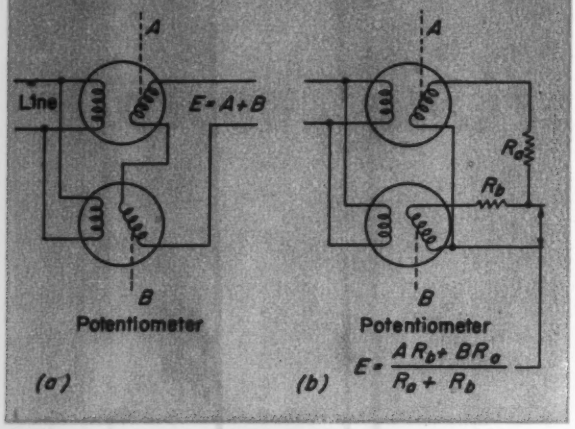


Fig. 3—Above—Typical standard mechanical differentials. Depending on size, backlash in these units, with precision gearing, ranges between 2 to 9 minutes of arc, measured with gear train locked

Fig. 4—Below—When sum or difference is desired as a voltage, potentiometers are driven by each of the input shafts, with the outputs connected in series as at (a). Another method (b) has summing resistors connected from a common point



ables concerned, and so the man interested in industrial equipment is apt to think there is nothing there that he might build into his machines. Often he is right, but it is something on which he should not make an uninformed decision.

The best method of performing an arithmetic operation depends largely upon the form in which the input quantities are available, their physical location with respect to each other, the place where the output quantities are needed, and the form in which the outputs are desired. Mechanical components, such as cams, mechanical resolvers and integrators are well known and are extremely useful.

One advantage of electromechanical computers is that accuracy is built into the components themselves. Application to a machine requires only good gearing, which does not put the burden on the machinist that items such as cams and slides do. If split gears are used for low speed drives, even center distances can have reasonable tolerances. Any shop can build a computer of high accuracy and speed with these components.

Types of electromechanical units available are synchros, resolvers, booster amplifiers, induction potentiometers, induction generators, servo motors, servo amplifiers, servo damps and mechanical differentials.

Synchros for Transmitting Data

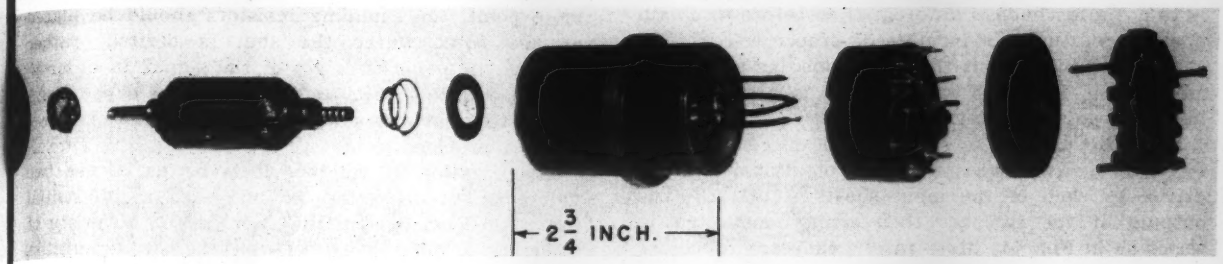
Synchros used in computers are of three general types; transmitters, receivers or control transformers, and differentials. They are used primarily for the transmission of data from one point to another. A somewhat more detailed description will be given in the discussion of methods of addition and subtraction.

In the solution of trigonometric problems, resolvers are employed. When excited, a resolver has an output proportional to the sine of the angle through which it is turned from its null position. Booster amplifiers are used in chains of components to avoid the errors due to loading.

In construction, a resolver is similar to a two-phase wound-rotor induction motor. In fact, such a motor can be used as a resolver if the accuracy requirements are not high. In increasing the accuracy from one or two per cent to something better than a tenth of a per cent, maintaining this over a large range of exitation voltage and temperature and keeping the output free from excessive quadrature and harmonic voltages, many refinements in construction and circuits become necessary.

An induction potentiometer has an output proportional to the angle through which it is rotated from its zero position. Its construction is similar to that of a resolver with a single input and a single output and a different distribution of the windings.

An induction generator is a generator composed of a cup which is rotated in an alternating magnetic field. The voltage induced in a winding perpendicular to the exciting winding is proportional to



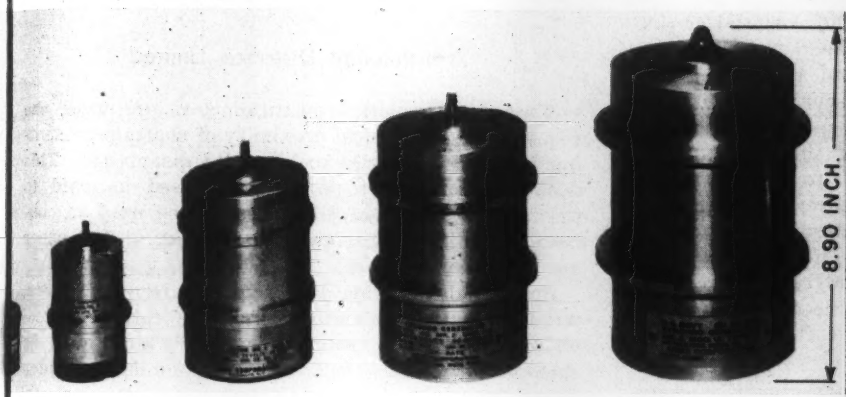


Fig. 5—Above—Exploded view of a standard induction potentiometer

Fig. 6—Left—Standard synchro units for either 115-volt 60-cycle or 24-volt 400-cycle electrical supply

the speed of rotation of the cup. One type has a cup rotated in a d-c field and has an output proportional to acceleration.

Servo motors are of several types and many sizes, and are used to drive other computing elements to obtain a solution to the problem that has been introduced. Servo amplifiers and servo damps are used in connection with them.

Although a mechanical differential is purely mechanical, it is used so often in electromechanical computers that it has become an electromechanical computing element by courtesy.

For convenience in illustrating the uses of the various components, certain conventional representations have come into use. These are illustrated in *Fig.* 1. Electrical connections between units are represented by solid lines, while mechanical connections are represented by dotted lines. Gear ratios are not usually shown but suitable ones are assumed to be incorporated in the mechanical lines. Relative speeds are usually indicated only where they are essential to an understanding of the computer in question.

The term relative speed is used often in computer and servo work. The gun mount in *Fig.* 2*a* is driven by a worm shaft which makes 120 revolutions for one revolution of the gun. This shaft in turn is driven by a motor which makes 576 revolutions for the same gun revolution. Then the worm shaft is referred to as a 120-speed shaft, and the motor as a 576-speed motor.

In the case of a nonrotational motion, as the movement of a lathe carriage along its bed, unit speed can be taken as that of a shaft which makes one revolution for the total travel of the carriage. *Fig.* 2*b* shows a case in which a 200-speed screw drives the carriage, and in which a 1-speed and a 25-speed synchro are provided, with a 1920-speed servo.

All computations can be reduced to combinations of the fundamental operations of arithmetic. In fact, they can all be reduced to the repeated operations of addition and subtraction, but this is rarely advisable. As Carlyle said of Mill's *Economics,* "It is like doing cube root in Roman numerals; it can be done, but it isn't worth doing." However, the operations of addition and subtraction are required in almost every computation, so the methods of performing these will be considered first.

Addition and Subtraction

When two quantities are to be added or subtracted and are available at the same place as shaft rotations, assuming the output is desired as a shaft rotation, the simplest solution is the use of a mechanical differential. The error introduced by gear eccentricity, backlash, and spring due to loading can be reduced to low limits by proper choice of an operating speed. As long as inertia of the parts is not important, gear error and backlash are inversely proportional to the relative speed at which the differential is operated. However, errors due to spring vary inversely as the square of the relative speed because the torque on the differential is reduced and the resultant deflection at unit speed is also reduced by the gear ratio. A group of standard differentials are shown in *Fig.* 3.

A second case is when two quantities are available at the same point as shaft rotations but the sum or difference is desired as an electrical voltage. In this case there are two simple solutions. The first

is to use a mechanical differential as before to obtain a shaft rotation. As mentioned, proper selection of gear ratios will permit this to be done as accurately as desired. Then the output shaft is geared to an induction potentiometer.

It is also possible to eliminate the mechanical differential and to use induction potentiometers, one driven by each of the input shafts *A* and *B*. The outputs of the two are then simply connected in series as in *Fig.* 4*a*. More rarely, they are connected as in *Fig.* 4*b* in which a separate resistor is connected from a common point to each of the potentiometers whose outputs are to be added. The potential of this common point then becomes the average of the outputs of the various units, provided all the resistors are equal. If they are not, the several outputs are weighted inversely as their corresponding resistors.

Since the output impedances of the induction potentiometers themselves are subject to some variation, it is necessary that the summing resistors be large compared with any possible variation in the potentiometer impedances. In this requirement lies the principal objection to this method of summing the outputs. In cases where the sum is needed at a remote point, the summing resistors should be placed at the point where the sum is desired, rather than at the point of origin of the signal, in order to minimize the effect of line interference, capacitance, etc. Procurement of suitably precise resistors is sometimes a problem.

The question of whether it is better to use two induction potentiometers or one with a differential can be decided by determination of the difficulty of inserting a differential between the two quantities to be added. If this insertion is simple, it is practically always preferable.

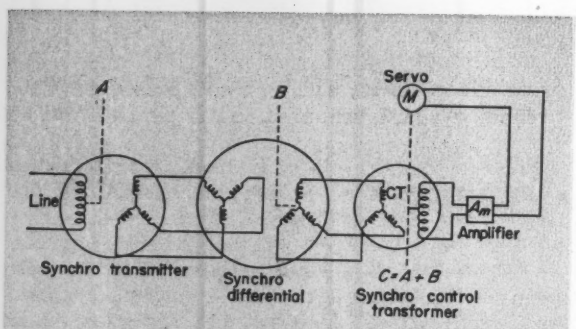
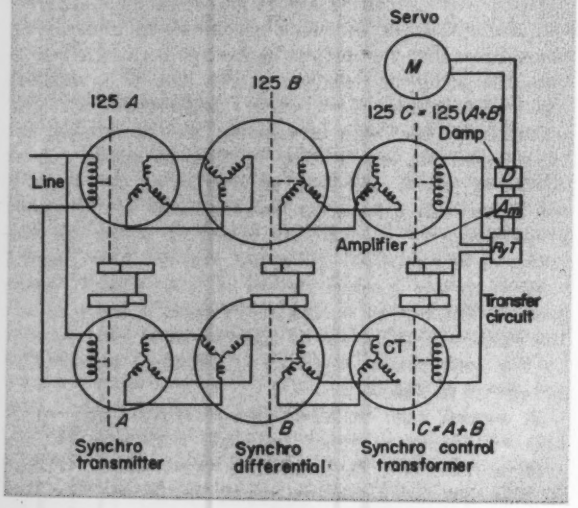


Fig. 7—Above—Schematic of circuit for addition, using a synchro differential

Fig. 8—Below—Circuit for addition with high and low-speed synchro differentials



Transmission Distance Limited

When two induction potentiometers are used, the requirement of physical proximity of shafts representing the two quantities to be added disappears. This does not mean that no attention need be paid to the length or kind of transmission line used to connect the units, but a few feet one way or the other are of no consequence.

Being high-precision 400-cycle signal transformers, Arma induction potentiometers have ratios of secondary voltage to primary voltage which may be varied continuously between fixed minus and plus values by mechanical rotation of a projecting shaft. These ratios are exact linear functions of the angular displacement of the shaft, within the inherent accuracy tolerances, from −45 degrees to +45 degrees. Rotation may be continuous and in either direction.

Construction of the induction potentiometer is essentially simple as shown in *Fig.* 5. The unit consists of a wound rotor which is excited at a voltage of about twenty volts or less and a wound stator in which the rotor turns. As the rotor turns, the coupling between it and the stator varies in such a way as to give an output voltage proportional to the excitation voltage and to the angle through which the rotor is turned from the position of minimum coupling. This characteristic is obtained by proper distribution of the rotor and stator windings. The slip rings and brushes, through which current is fed to the rotor, are of materials that are not subject to corrosion or tarnish, insuring low contact resistance at all time.

Accuracy Is Greater

The question is sometimes raised as to why induction potentiometers are employed rather than the relatively inexpensive resistance units that are so readily obtainable. There are a number of reasons. The first is the service life obtainable. A resistance potentiometer has a brush which slides over a resistance wire or plastic. As time goes on the brush and the resistance wire wear, and the resistances will change. One million revolutions is considered a reasonable life for such a unit. For many purposes this life is adequate but it would not be satisfactory for application to a machine operating on a three or four-second cycle nor for use in a shipboard application where the rotor follows the roll or pitch of a ship.

(*Continued on Page* 174)

Standard Tolerances for

MOLDED PLASTICS

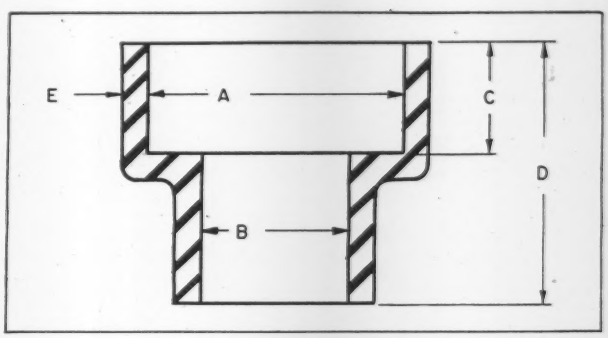
TO provide information necessary for specifying tolerances for molded plastics parts, The Society of the Plastics Industry, Inc., has surveyed many molding plants for representative data. The results of this work covering molding tolerance and dimensional stability of molded thermoplastics and thermosetting parts, excluding laminates, are given in this Data Sheet.

A specimen drawing of a part devised to encompass a variety of tolerance conditions is shown at the right. While it is recognized that the selected specimen drawing does not cover all possible conditions, it does provide a practical working basis upon which molding tolerance standards may be established.

Because each plastic material is different in character to some extent from all others and because design varies widely, it is difficult to establish overall tolerances for molding in general. Consequently, each material is charted specially as to practical attainable tolerances in production. These have been subdivided as:

1. *Fine.* Closest possible limits commensurate with closely supervised and controlled production. Highest cost
2. *Standard.* Usual commercial tolerance that can be held under average molding conditions. Medium cost
3. *Coarse.* Conditions of broad variation where accurate dimensions are not the primary factor. Lowest cost.

It is, of course, obvious that the closer the tolerances, the higher the production costs in dies, tooling and molding control. Too, all the various factors which accumulate to increase the molding variations must be considered. Generally, aging or stability factors are not included in these tables. The tolerances shown do *not* apply to screw threads, location of inserts or warpage.



CELLULOSE ACETATE, MEDIUM FLOW

Drawing Code	Dimension		Plus or Minus in Thousandths of an Inch
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000 - 0.500 0.500 - 1.000 1.000 - 2.000 2.000 - 3.000 3.000 - 4.000 4.000 - 5.000 5.000 - 6.000		1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 FINE / STANDARD / COARSE
	Over 6 in. Add Per Inch	Fine	0.003 in.
		Standard	0.005 in.
		Coarse	0.007 in.
	Draft allowance per side	Fine	¼ Degree
		Standard	½ Degree
		Coarse	1 Degree
			Plus or Minus in Thousandths of an Inch 1 2 3 4 5 6 7 8 9 10 12 14 16 18 20
D	Single Cavity Height 0.000 - 1.000 in.		Fine / St'd / Coarse
D	Multiple Cavities Height 0.000 - 1.000 in.		Fine / St'd / Coarse
D	Added Height		0.002 in. per in.
E	Section Thickness to be held constant ± 0.001 in.		

WOODFLOUR - FILLED PHENOLIC MATERIALS

Drawing Code	Dimension in inches*		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH
			1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 FINE / STANDARD / COARSE
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000		
	Over 6 in. add per inch	Fine	0.0015 in.
		Standard	0.002 in.
		Coarse	0.0025 in.
			* When dimension is greater than that shown use next larger tolerance.
	Draft allowance per side	Fine	¼ Degree
		Standard	½ Degree
		Coarse	1 Degree
E	Section thickness to be held constant.		
E[1]	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this.		

Drawing Code	[2] Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH
			2 4 6 8 10 12 14 16 18 20 22
D	Single cavity		Fine / St'd / Coarse
D	Multiple cavity		Fine / St'd / Coarse
D	For cavity depth more than 1.000 inch		Add 0.002 in. per in.
	For projected area over 20 square inches	Fine	Add 0.001 in. for each additional 10 sq. inches
		St'd	Add 0.002 in. for each additional 10 sq. inches
		Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH 2 4 6 8 10 12 14 16 18 20 22
D	Single cavity		Fine / St'd / Coarse
D	Multiple cavity		Fine / St'd / Coarse
	If cavity depth exceeds 1 inch		Add 0.001 in. per in.
E[2]	Section thickness tolerance same as "D"		

COTTON - FLOCK - FILLED PHENOLIC MATERIALS

Drawing Code	Dimension in inches*	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19)
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500	FINE / STANDARD / COARSE
	0.500-1.000	
	1.000-2.000	
	2.000-3.000	
	3.000-4.000	
	4.000-5.000	
	5.000-6.000	
	Over 6 in. add per inch: Fine	0.0015 in.
	Standard	0.002 in.
	Coarse	0.0025 in.
	* When dimension is greater than that shown use next larger tolerance.	
	Draft allowance per side: Fine	1/8 Degree
	Standard	1/4 Degree
	Coarse	1 Degree
E	Section thickness to be held constant	
E[1]	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this	

Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
D	For cavity depth more than 1.000 inch	Add 0.002 in. per in.
	For projected area over 20 square inches: Fine	Add 0.001 in. for each additional 10 sq. inches
	St'd	Add 0.002 in. for each additional 10 sq. inches
	Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
	If cavity depth exceeds 1 inch	Add 0.0015 in. per in.
E[2]	Section thickness tolerance same as "D"	

COTTON RAG FILLED PHENOLIC MATERIALS

Drawing Code	Dimension in inches*	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19)
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500	FINE / STANDARD / COARSE
	0.500-1.000	
	1.000-2.000	
	2.000-3.000	
	3.000-4.000	
	4.000-5.000	
	5.000-6.000	
	Over 6 in. add per inch: Fine	0.002 in.
	Standard	0.0025 in.
	Coarse	0.003 in.
	* When dimension is greater than that shown use next larger tolerance.	
	Draft allowance per side: Fine	1/8 Degree
	Standard	1/4 Degree
	Coarse	1 Degree
E	Section thickness to be held constant	
E[1]	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this	

Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse*
D	For cavity depth more than 1.000 inch	Add 0.002 in. per in.
	For projected area over 20 square inches: Fine	Add 0.001 in. for each additional 10 sq. inches
	St'd	Add 0.002 in. for each additional 10 sq. inches
	Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
	If cavity depth exceeds 1 inch	Add 0.0015 in. per in.
E[2]	Section thickness tolerance same as "D"	

COTTON TIRE CORD FILLED PHENOLIC MATERIALS

Drawing Code	Dimension in inches*	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19)
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500	FINE / STANDARD / COARSE
	0.500-1.000	
	1.000-2.000	
	2.000-3.000	
	3.000-4.000	
	4.000-5.000	
	5.000-6.000	
	Over 6 in. add per inch: Fine	0.0015 in.
	Standard	0.002 in.
	Coarse	0.0025 in.
	* When dimension is greater than that shown use next larger tolerance.	
	Draft allowance per side: Fine	1/8 Degree
	Standard	1/4 Degree
	Coarse	1 Degree
E	Section thickness to be held constant	
E[1]	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this	

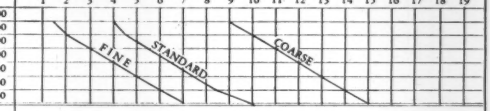
Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
D	For cavity depth more than 1.000 inch	Add 0.002 in. per in.
	For projected area over 20 square inches: Fine	Add 0.001 in. for each additional 10 sq. inches
	St'd	Add 0.002 in. for each additional 10 sq. inches
	Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
	If cavity depth exceeds 1 inch	Add 0.0015 in. per in.
E[2]	Section thickness tolerance same as "D"	

MACERATED PAPER FILLED PHENOLIC MATERIALS

Drawing Code	Dimension in inches*	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19)
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500	FINE / STANDARD / COARSE
	0.500-1.000	
	1.000-2.000	
	2.000-3.000	
	3.000-4.000	
	4.000-5.000	
	5.000-6.000	
	Over 6 in. add per inch: Fine	0.002 in.
	Standard	0.0025 in.
	Coarse	0.003 in.
	* When dimension is greater than that shown use next larger tolerance.	
	Draft allowance per side: Fine	1/8 Degree
	Standard	1/4 Degree
	Coarse	1 Degree
E	Section thickness to be held constant	
E[1]	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this	

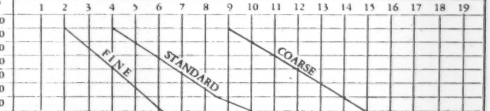
Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
D	For cavity depth more than 1.000 inch	Add 0.002 in. per in.
	For projected area over 20 square inches: Fine	Add 0.001 in. for each additional 10 sq. inches
	St'd	Add 0.002 in. for each additional 10 sq. inches
	Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
	If cavity depth exceeds 1 inch	Add 0.0015 in. per in.
E[2]	Section thickness tolerance same as "D"	

SHORT - FIBER - ASBESTOS - FILLED PHENOLIC MATERIALS

Drawing Code	Dimension in inches*	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19)
Cylindrical and linear dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000	
	Over 6 in. add per inch: Fine	0.001 in.
	Standard	0.0015 in.
	Coarse	0.002 in.
	* When dimension is greater than that shown use next larger tolerance.	
Draft allowance per side	Fine	¼ Degree
	Standard	½ Degree
	Coarse	1 Degree
E	Section thickness to be held constant.	
E¹	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this.	

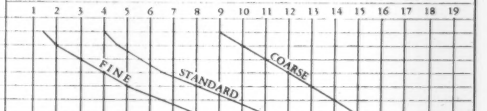
Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine | Std Coarse
D	Multiple cavity	Fine | Std Coarse
D	For cavity depth more than 1.000 inch	Add 0.002 in. per in.
	For projected area over 20 square inches: Fine	Add 0.001 in. for each additional 10 sq. inches
	Std	Add 0.002 in. for each additional 10 sq. inches
	Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine | Std Coarse
D	Multiple cavity	Fine | Std Coarse
	If cavity depth exceeds 1 inch	Add 0.001 in. per in.
E²	Section thickness tolerance same as "D"	

LONG - FIBER - ASBESTOS - FILLED PHENOLIC MATERIALS

Drawing Code	Dimension in inches*	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19)
Cylindrical and linear dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000	
	Over 6 in. add per inch: Fine	0.001 in.
	Standard	0.0015 in.
	Coarse	0.002 in.
	* When dimension is greater than that shown use next larger tolerance.	
Draft allowance per side	Fine	⅛ Degree
	Standard	¼ Degree
	Coarse	1 Degree
E	Section thickness to be held constant.	
E¹	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this.	

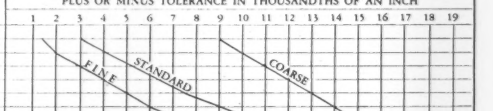
Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine | Std Coarse
D	Multiple cavity	Fine | Std Coarse
D	For cavity depth more than 1.000 inch	Add 0.002 in. per in.
	For projected area over 20 square inches: Fine	Add 0.001 in. for each additional 10 sq. inches
	Std	Add 0.002 in. for each additional 10 sq. inches
	Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine | Std Coarse
D	Multiple cavity	Fine | Std Coarse
	If cavity depth exceeds 1 inch	Add 0.001 in. per in.
E²	Section thickness tolerance same as "D"	

ASBESTOS - WOODFLOUR - FILLED PHENOLIC MATERIALS

Drawing Code	Dimension in inches*	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19)
Cylindrical and linear dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000	
	Over 6 in. add per inch: Fine	0.0015 in.
	Standard	0.002 in.
	Coarse	0.0025 in.
	* When dimension is greater than that shown use next larger tolerance.	
Draft allowance per side	Fine	⅛ Degree
	Standard	¼ Degree
	Coarse	1 Degree
E	Section thickness to be held constant.	
E¹	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this.	

Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine | Std Coarse
D	Multiple cavity	Fine | Std Coarse
D	For cavity depth more than 1.000 inch	Add 0.002 in. per in.
	For projected area over 20 square inches: Fine	Add 0.001 in. for each additional 10 sq. inches
	Std	Add 0.002 in. for each additional 10 sq. inches
	Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine | Std Coarse
D	Multiple cavity	Fine | Std Coarse
	If cavity depth exceeds 1 inch	Add 0.001 in. per in.
E²	Section thickness tolerance same as "D"	

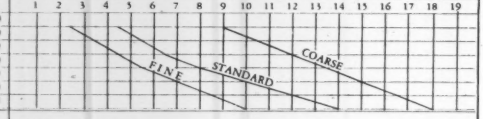
MICA - FILLED PHENOLIC MATERIALS

Drawing Code	Dimension in inches*	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19)
Cylindrical and linear dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000	
	Over 6 in. add per inch: Fine	0.001 in.
	Standard	0.0015 in.
	Coarse	0.002 in.
	* When dimension is greater than that shown use next larger tolerance.	
Draft allowance per side	Fine	⅛ Degree
	Standard	¼ Degree
	Coarse	1 Degree
E	Section thickness to be held constant.	
E¹	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this.	

Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine | Std Coarse
D	Multiple cavity	Fine | Std Coarse
D	For cavity depth more than 1.000 inch	Add 0.002 in. per in.
	For projected area over 20 square inches: Fine	Add 0.001 in. for each additional 10 sq. inches
	Std	Add 0.002 in. for each additional 10 sq. inches
	Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine | Std Coarse
D	Multiple cavity	Fine | Std Coarse
	If cavity depth exceeds 1 inch	Add 0.001 in. per in.
E²	Section thickness tolerance same as "D"	

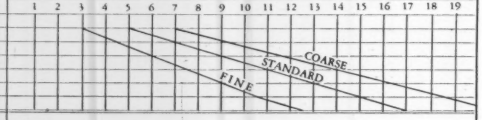
Molded Plastics

UNFILLED PHENOLIC MATERIALS

Drawing Code	Dimension in inches*		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000		
	Over 6 in. add per inch	Fine	0.0015 in.
		Standard	0.002 in.
		Coarse	0.0025 in.
	* When dimension is greater than that shown use next larger tolerance.		
	Draft allowance per side	Fine	½ Degree
		Standard	¼ Degree
		Coarse	1 Degree
E	Section thickness to be held constant		
E¹	Wall thickness eccentricity 0.005 0.007 in. Interlocking reduces this.		

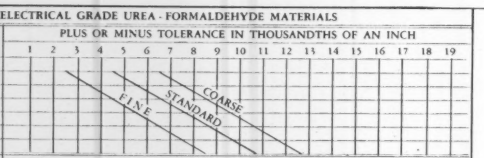
Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH 2 4 6 8 10 12 14 16 18 20 22
D	Single cavity		Fine | St'd | Coarse
D	Multiple cavity		Fine | St'd | Coarse
D	For cavity depth more than 1.000 inch		Add 0.002 in. per in.
	For projected area over 20 square inches	Fine	Add 0.001 in. for each additional 10 sq. inches
		St'd	Add 0.002 in. for each additional 10 sq. inches
		Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH 2 4 6 8 10 12 14 16 18 20 22
D	Single cavity		Fine | St'd | Coarse
D	Multiple cavity		Fine | St'd | Coarse
	If cavity depth exceeds 1 inch		Add 0.001 in. per in.
E²	Section thickness tolerance same as "D"		

ALPHA CELLULOSE FILLED UREA - FORMALDEHYDE MATERIALS

Drawing Code	Dimension in inches*		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000		
	Over 6 in. add per inch	Fine	0.004 in.
		Standard	0.006 in.
		Coarse	0.008 in.
	* When dimension is greater than that shown use next larger tolerance.		
	Draft allowance per side	Fine	¼ Degree
		Standard	½ Degree
		Coarse	1 Degree
E	Section thickness to be held constant.		
E¹	Wall thickness eccentricity 0.005 0.007 in. Interlocking reduces this.		

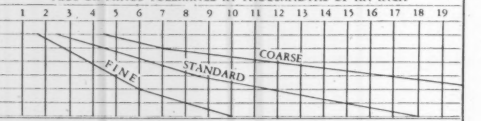
Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH 2 4 6 8 10 12 14 16 18 20 22
D	Single cavity		Fine | St'd | Coarse
D	Multiple cavity		Fine | St'd
D	For cavity depth more than 1.000 inch		
	For projected area over 20 square inches	Fine	Add 0.002 in. for each additional 10 sq. inches
		St'd	Add 0.003 in. for each additional 10 sq. inches
		Coarse	Add 0.004 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH 2 4 6 8 10 12 14 16 18 20 22
D	Single cavity		Fine | St'd | Coarse
D	Multiple cavity		Fine | St'd | Coarse
	If cavity depth exceeds 1 inch		
E²	Section thickness tolerance same as "D"		

ELECTRICAL GRADE UREA - FORMALDEHYDE MATERIALS

Drawing Code	Dimension in inches*		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000		
	Over 6 in. add per inch	Fine	0.005 in.
		Standard	0.007 in.
		Coarse	0.009 in.
	* When dimension is greater than that shown use next larger tolerance.		
	Draft allowance per side	Fine	⅛ Degree
		Standard	¼ Degree
		Coarse	1 Degree
E	Section thickness to be held constant.		
E¹	Wall thickness eccentricity 0.005 0.007 in. Interlocking reduces this.		

Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH 2 4 6 8 10 12 14 16 18 20 22
D	Single cavity		Fine | St'd | Coarse
D	Multiple cavity		Fine | St'd | Coarse
D	For cavity depth more than 1.000 inch		Add 0.002 in. per in.
	For projected area over 20 square inches	Fine	Add 0.001 in. for each additional 10 sq. inches
		St'd	Add 0.002 in. for each additional 10 sq. inches
		Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH 2 4 6 8 10 12 14 16 18 20 22
D	Single cavity		Fine | St'd | Coarse
D	Multiple cavity		Fine | St'd | Coarse
	If cavity depth exceeds 1 inch		Add 0.001 in. per in.
E²	Section thickness tolerance same as "D"		

CELLULOSE - FILLED MELAMINE - FORMALDEHYDE MATERIALS

Drawing Code	Dimension in inches*		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000		
	Over 6 in. add per inch	Fine	0.002 in.
		Standard	0.003 in.
		Coarse	0.006 in.
	* When dimension is greater than that shown use next larger tolerance.		
	Draft allowance per side	Fine	⅛ Degree
		Standard	¼ Degree
		Coarse	1 Degree
E	Section thickness to be held constant 0.004 in.		
E¹	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this.		

Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH 2 4 6 8 10 12 14 16 18 20 22
D	Single cavity		Fine | St'd | Coarse
D	Multiple cavity		Fine | St'd | Coarse
D	For cavity depth more than 1.000 inch		Add 0.002 in. per in.
	For projected area over 20 square inches	Fine	Add 0.002 in. for each additional 10 sq. inches
		St'd	Add 0.003 in. for each additional 10 sq. inches
		Coarse	Add 0.005 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH 2 4 6 8 10 12 14 16 18 20 22
D	Single cavity		Fine | St'd | Coarse
D	Multiple cavity		Fine | St'd | Coarse
	If cavity depth exceeds 1 inch		Add 0.002 in. per in.
E²	Section thickness tolerance same as "D"		

ASBESTOS - FILLED MELAMINE - FORMALDEHYDE MATERIALS

Drawing Code	Dimension in inches*	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19)
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000	FINE / STANDARD / COARSE
	Over 6 in. add per inch: Fine	0.004 in.
	Standard	0.005 in.
	Coarse	0.007 in.
	* When dimension is greater than that shown use next larger tolerance.	
	Draft allowance per side: Fine	¼ Degree
	Standard	¼ Degree
	Coarse	1 Degree
E	Section thickness to be held constant 0.004 in	
E¹	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this.	

Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
D	For cavity depth more than 1.000 inch	Add 0.002 in. per in.
	For projected area over 20 square inches: Fine	Add 0.002 in. for each additional 10 sq. inches
	St'd	Add 0.004 in. for each additional 10 sq. inches
	Coarse	Add 0.006 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
	If cavity depth exceeds 1 inch	Add 0.002 in. per in.
E²	Section thickness tolerance same as "D"	

COTTON - RAG - FILLED MELAMINE - FORMALDEHYDE MATERIALS

Drawing Code	Dimension in inches*	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19)
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000-0.500 0.500-1.000 1.000-2.000 2.000-3.000 3.000-4.000 4.000-5.000 5.000-6.000	FINE / STANDARD / COARSE
	Over 6 in. add per inch: Fine	0.002 in.
	Standard	0.0025 in.
	Coarse	0.003 in.
	* When dimension is greater than that shown use next larger tolerance.	
	Draft allowance per side: Fine	¼ Degree
	Standard	¼ Degree
	Coarse	1 Degree
E	Section thickness to be held constant.	
E¹	Wall thickness eccentricity 0.005 - 0.007 in. Interlocking reduces this.	

Drawing Code	Compression molded. Cavity depth 0.000-1 inch Projected area up to 20 square inches	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
D	For cavity depth more than 1.000 inch	Add 0.002 in. per in.
	For projected area over 20 square inches: Fine	Add 0.001 in. for each additional 10 sq. inches
	St'd	Add 0.002 in. for each additional 10 sq. inches
	Coarse	Add 0.003 in. for each additional 10 sq. inches
	Transfer, Jet, or Injection molded Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (2 4 6 8 10 12 14 16 18 20 22)
D	Single cavity	Fine / St'd / Coarse
D	Multiple cavity	Fine / St'd / Coarse
	If cavity depth exceeds 1 inch	Add 0.0015 in. per in.
E²	Section thickness tolerance same as "D"	

CELLULOSE ACETATE BUTYRATE, MEDIUM FLOW

Drawing Code	Dimension	Plus or Minus in Thousandths of an Inch (1 2 3 4 5 6 7 8 9 10 12 14 16 18 20)
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000 - 0.500 0.500 - 1.000 1.000 - 2.000 2.000 - 3.000 3.000 - 4.000 4.000 - 5.000 5.000 - 6.000	FINE / STANDARD / COARSE
	Over 6 in. Add Per Inch: Fine	0.003 in.
	Standard	0.004 in.
	Coarse	0.007 in.
	Draft allowance per side: Fine	⅛ Degree
	Standard	¼ Degree
	Coarse	1 Degree
		Plus or Minus in Thousandths of an Inch (1 2 3 4 5 6 7 8 9 10 12 14 16 18 20)
D	Single Cavity Height 0.000 - 1.000 in.	Fine / St'd / Coarse
D	Multiple Cavities Height 0.000 - 1.000 in.	Fine / St'd / Coarse
D	Added Height	0.002 in. per in.
E	Section Thickness to be held constant ± 0.001 in.	

ETHYL CELLULOSE, MEDIUM FLOW

Drawing Code	Dimension	Plus or Minus in Thousandths of an Inch (1 2 3 4 5 6 7 8 9 10 12 14 16 18 20)
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000 - 0.500 0.500 - 1.000 1.000 - 2.000 2.000 - 3.000 3.000 - 4.000 4.000 - 5.000 5.000 - 6.000	COARSE / STANDARD / FINE
	Over 6 in. Add Per Inch: Fine	0.0025 in.
	Standard	0.0045 in.
	Coarse	0.007 in.
	Draft allowance per side: Fine	⅛ Degree
	Standard	½ Degree
	Coarse	1 Degree
		Plus or Minus in Thousandths of an Inch (1 2 3 4 5 6 7 8 9 10 12 14 16 18 20)
D	Single Cavity Height 0.000 - 1.000 in.	Fine / St'd / Coarse
D	Multiple Cavities Height 0.000 - 1.000 in.	Fine / St'd / Coarse
D	Added Height	0.002 in. per in.
E	Section Thickness to be held constant ± 0.001 in.	

METHYL METHACRYLATE, GENERAL PURPOSE

Drawing Code	Dimension	Plus or Minus in Thousandths of an Inch (1 2 3 4 5 6 7 8 9 10 12 14 16 18 20)
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000 - 0.500 0.500 - 1.000 1.000 - 2.000 2.000 - 3.000 3.000 - 4.000 4.000 - 5.000 5.000 - 6.000	FINE / STANDARD / COARSE
	Over 6 in. Add Per Inch: Fine	0.002 in.
	Standard	0.004 in.
	Coarse	0.006 in.
	Draft allowance per side: Fine	¼ Degree
	Standard	½ Degree
	Coarse	1 Degree
		Plus or Minus in Thousandths of an Inch (1 2 3 4 5 6 7 8 9 10 12 14 16 18 20)
D	Single Cavity Height 0.000 - 1.000 in.	Fine / St'd / Coarse
D	Multiple Cavities Height 0.000 - 1.000 in.	Fine / St'd / Coarse
D	Added Height	0.002 in. per in.
E	Section Thickness to be held constant ± 0.001 in.	

POLYSTYRENE, UNPLASTICIZED

Drawing Code	Dimension	Plus or Minus in Thousandths of an Inch (1 2 3 4 5 6 7 8 9 10 12 14 16 18 20)
Cylindrical and lineal dimensions (A, B, C) on straight draw, uniform moldings. No allowance for draft.	0.000 - 0.500 0.500 - 1.000 1.000 - 2.000 2.000 - 3.000 3.000 - 4.000 4.000 - 5.000 5.000 - 6.000	COARSE / STANDARD / FINE
	Over 6 in. Add Per Inch: Fine	0.002 in.
	Standard	0.004 in.
	Coarse	0.0065 in.
	Draft allowance per side: Fine	½ Degree
	Standard	1° Degree
	Coarse	1½ Degree
		Plus or Minus in Thousandths of an Inch (1 2 3 4 5 6 7 8 9 10 12 14 16 18 20)
D	Single Cavity Height 0.000 - 1.000 in.	Fine / St'd / Coarse
D	Multiple Cavities Height 0.000 - 1.000 in.	Fine / St'd / Coarse
D	Added Height	0.0015 in. per in.
E	Section Thickness to be held constant ± 0.001 in.	

MEN OF MACHINES

MACHINE DESIGN announces the appointment of **Benjamin L. Hummel** as associate editor. A mechanical engineering graduate of Lehigh University he was associated for ten years with the Hamilton Watch Co., Lancaster, Pa., having served as supervisor of Hamilton's watch design section during the past four years. He was engaged in the design of precision products for large volume manufacture and participated in all phases of product engineering work on specialized wartime instruments and regular watches. In the field of technical journalism, Mr. Hummel exercised his interest and talent by preparing articles and papers and by training student engineers to write effectively.

•

S. J. Alex, recently appointed chief engineer of the Vendorlator Mfg. Co., Fresno, Calif., previously served as liaison engineer designing and planning new methods in tooling required on high-speed production lines. In 1948 he was appointed chief engineer, a position he held up until a short time ago. As assistant chief engineer he played a part in designing the tooling required in the manufacture of coin-operated machines. He has had over fifteen years experience in the vending machine field, having also been affiliated with the Canteen Co. of America and the Vendall Co.

•

Appointment of **Arlo Israelson** as chief engineer of the Eriez Mfg. Co., Erie, Pa., has been announced. He succeeds **W. W. Mojden** now with Mills-Winfield Co. With the Eriez company, he will be responsible for the design of permanent nonelectric magnetic separation equipment for use in the textile, food, milling, metalworking, chemical and other industries. Mr. Israelson comes to Eriez from the Flynn Machine Co. Inc., San Jose, Calif., manufacturers of food machinery. He has also been associated with the Koppers Co. and a private firm of consulting engineers in Los Angeles.

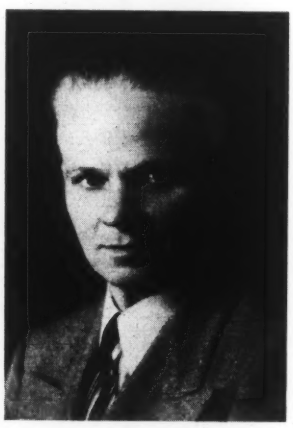
•

Paul Schwarzkopf, president of the American Electro Metal Corp., Yonkers, N. Y., has been awarded the annual medal given by Stevens Institute of Technology for outstanding achievement in the field of powder metallurgy. Graduated in 1910 from the In-

Benjamin L. Hummel

S. J. Alex

Arlo Israelson



stitute of Technology in Prague, Dr. Schwarzkopf took a position with an incandescent lamp factory where he first encountered metal powder used in the production of extruded filaments. A year later he formed his own company which was soon producing molybdenum and tungsten wires, developed the fine tungsten powder used in the ductile Wolfram-Pintsch filament, and introduced tungsten in ribbon form for ignition contacts at the Ford Motor Co. By the end of the 1920's Dr. Schwarzkopf's enterprises had offices in 36 countries. In 1929 he set up the American Electro Metal Corp. with offices in New York, and a wire manufacturing plant which was later sold to the North American Philips Co. A research laboratory and pilot plants in Yonkers were added later. Dr. Schwarzkopf is responsible for developing the Elmet metal, a heavy-duty material for electrical contacts, and Cutanit, a steel cutting multicarbide tool material which has increased cutting efficiency 16 times. In co-operation with government and industrial agencies he also developed compressor blades for axial-flow turbines.

♦

Election of **William L. Batt** as a director of American Standards Assn. has been announced. Mr. Batt, president of SKF Industries, Inc., Philadelphia, took a leading part in the standardization campaign that united the United States, Great Britain and Canada on the dimensions of ordinary screw threads.

♦

Henry W. Luetkemeyer, chief engineer, has been elected vice president of engineering of the Cleveland Graphite Bronze Co., Cleveland.

♦

Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., makers of steel mill equipment, castings, hydraulic presses, and crushers, has announced the appointment of **E. T. Peterson** as vice president in charge of engineering. Mr. Peterson has been associated with the company for 27 years, recently as chief engineer in the rolling mill department.

♦

Oliver W. Bonnafe was recently elected vice president in charge of research engineering for Lapointe Machine Tool Co., Hudson, Mass. Mr. Bonnafe has been associated with Lapointe for over 30 years and is well known for his contributions to the advancement of broaching.

♦

Robert H. Morse, Jr. has been named president of Fairbanks, Morse & Co., Chicago.

♦

Baker Industrial Truck Division of the Baker-Raulang Co., Cleveland, announces the election of **Robert H. Davies** as vice president and acting general manager and **Edward H. Remde** as vice president. Mr. Remde this year will complete 50 years of continuous service with Baker-Raulang. In 1900 he started as a draftsman for Baker Motor Vehicle Co. He was made chief draftsman in 1904, assistant chief engineer in 1915, chief engineer in 1918 and works manager in 1938. A picture and biographical sketch of Mr. Davies appeared in the October, 1949 issue of MACHINE DESIGN.

♦

Carl E. Swartz, formerly division engineer of the Kellex Corp., New York, has been named chairman of the metals research department at Armour Research Foundation of Illinois Institute of Technology. Dr. Swartz succeeds **W. E. Mahin** who was recently promoted from chairman of metals to director of research of the Foundation.

♦

Paul F. Bronckhurst has joined the staff of Kaiser Engineers, division of Kaiser Industries Inc., Oakland, Calif. Mr. Bronckhurst, a graduate of the Institute of Technology of Copenhagen, Denmark and a member of the American Society of Mechanical Engineers, began his engineering career in 1917 when he was associated with Nielsen and Winther. With over 30 years' experience, he has been chief engineer and consulting mechanical engineer for some of this country's leading equipment manufacturers.

♦

Announcement has been made of the appointment of **C. M. Baker** as chief engineer of Ingersoll Steel Div., Borg-Warner Corp., Kalamazoo, Mich. Mr. Baker succeeds **L. C. Freeman** who recently retired.

♦

A. K. Oppenheim of the Stanford Mechanical Engineering Department faculty has been awarded a prize by the Institute of Mechanical Engineers. The award was shared by Professor Oppenheim with **Joseph Kestin,** a professor at the Polish University in London. The two engineers were honored for a paper they wrote before Professor Oppenheim joined the Stanford faculty in 1948. The paper entitled "The Calculation of Compressible Fluid Flow by the Use of a Generalized Entropy Chart" introduces a graphical method of solving one-dimensional gas flow problems.

♦

Announcement has been made of the appointment of **James T. Eaton** as director of research of E. F. Houghton & Co., Philadelphia.

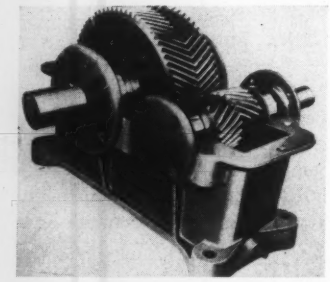
♦

Nicholas Kondur has been named manager of mold manufacture of the Plastics Division of General Electric's Chemical Dept. Mr. Kondur, formerly assistant to the president of Douglas Tool Co. in Detroit, is a graduate of the Henry Ford Trade School. He left Ford in 1932 to go with the Navy Dept. as a machinist, returned three years later as a draftsman and later became a tool designer. In 1942 he was with Frederick Coleman & Sons learning to build machines and from there went to the AMCO Gauge Co. as a designer, later being named superintendent. Previous to his employment with Douglas Tool Co. he was plant manager for the Valor Tool and Machine Co.

NEW PARTS AND MATERIALS

For additional information on these new developments see Page 157

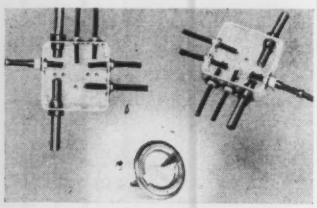
Herringbone Speed Reducer



Conveyors, generators, blowers, pumps, machine tools, cranes, agitators and similar equipment can be powered through these herringbone gear speed reducers. They are available in single, double and triple reduction units rated from ½ to 1000 hp, with center distances from 4 to 36 in. All shafts turn on high capacity antifriction bearings. Output bearings of standard torque units are designed to carry medium overhung loads. Overhung load type units use double-row tapered roller bearings. Gears are electric steel castings or high carbon steel forgings. Pinions and pinion shafts are cut integrally from heat-treated chrome-molybdenum steel. Manufacturer: De Laval Steam Turbine Co., Trenton 2, N. J.

For additional information circle MD 1 on Page 157

Strain Relief Bushing Adapters



Designed to fit into standard knockout box holes, adapters are available with various size holes to hold the complete line of Heyco strain relief bushings for anchoring wires such as POSJ, SV, SJ and HPD. Use of these adapters and Underwriters' approved bushings protects electrical appliances and machines from failure caused by faulty connections. Adapters and bushings securely anchor wire to knockout box and absorb pull, push and torque. Illustration shows adapter and various size wires anchored to standard junction box with adapters. Manufacturer: Heyman Mfg. Co., 100 Michigan Ave., Kenilworth, N. J.

For additional information circle MD 2 on Page 157

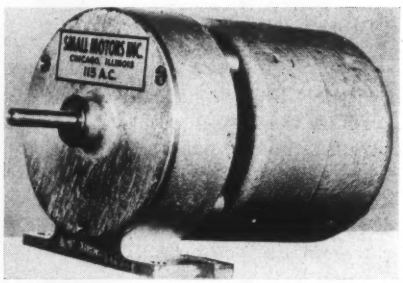
Nickel-Clad Copper Wire

Combining the electrical conductivity of copper with the heat and corrosion resistant properties of nickel, Kulgrid nickel-clad copper wire is obtainable in diameters from 0.010 to 0.005-in. These sizes are particularly suitable for stranding and for lead wire applications where high temperature working of hard glass frequently renders solid copper wires brittle and unworkable. Stranded conductors of this wire can be used as electrical leads for aircraft, electric furnaces, appliances, jet engines and wide variety of laboratory and industrial equipment. Manufacturer: Sylvania Electric Products Inc., Parts Div., Warren, Pa.

For additional information circle MD 3 on Page 157

Small Geared Motor

Suitable for applications requiring from 1 to 200 rpm, this small motor is obtainable with gears totally enclosed or with open gears. Powered by 115 or 220-v 50/60-cycle shaded-pole motor, unit delivers 6 lb-in. at 150 rpm. It has sleeve bearings with large

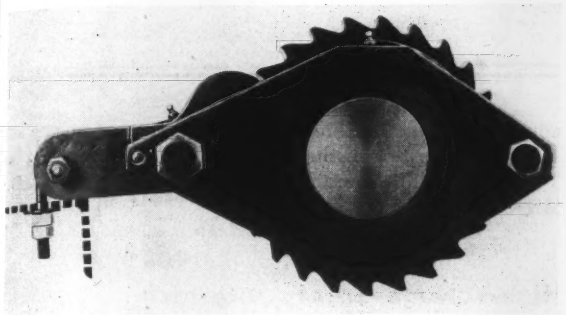


oil reservoir. Gearheads run in grease and have ¼-in. diameter output shaft in line with motor shaft. Measuring 3⅝ x 3¾ x 5-in. long less shaft, motor weighs 5 lb. Manufacturer: Small Motors Inc., 2076 Elston Ave., Chicago 14, Ill.

For additional information circle MD 4 on Page 157

Ratchet Type Backstop

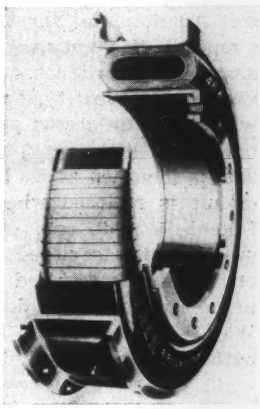
Taper-bushed to shaft size, this simplified backstop automatically prevents backing-up or running away of inclined conveyors, bucket elevators and similar equipment. Ratchet-type device operates automatically when power interruption, overload cutout or failure of prime mover occurs. Upon shaft reversal, the pawl engages the ratchet, locks the shaft in place and holds it in position until forward power is again applied. As long as shaft is turning in proper direction, pawl is entirely disengaged from ratchet so that there is no drag, vibration or noise. Unit can be



mounted in any position on head shaft and operates smoothly without transmitting shock to driven machine. Manufacturer: American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa.

For additional information circle MD 5 on Page 157

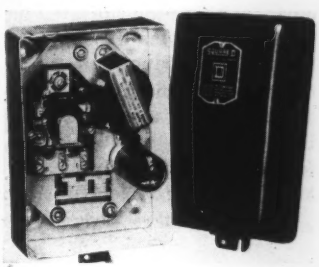
Flexible Coupling



Improvements in rubber composition and bonding have increased the torque capacity of this Airflex flexible coupling 20 per cent above previous models. Redesigned hubs and adapter plates facilitate disconnection and removal of entire gland assembly. All redesigned components are interchangeable with equivalent parts now in use. Standard parts can be combined to allow six different mounting arrangements including flange mounting on flywheel. Stiffness factors can be controlled. Coupling is designed for engine drives and applications involving extremely severe torque fluctuations. Manufacturer: Falk Corp., Milwaukee 8, Wis.

For additional information circle MD 6 on Page 157

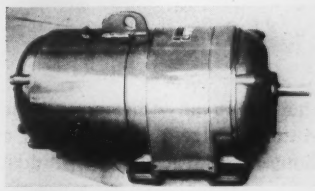
Low-Voltage Time-Delay Relay



Designed for use with a separate motor starter and pushbutton station, this low-voltage time-delay release relay provides automatic restarting of alternating current motors to 200 hp after momentary voltage fluctuation or a power failure lasting a few seconds. If power failure is prolonged the relay circuit disconnects the motor from the line to protect against unexpected restarting upon restoration of power. Adjustable to give approximately 2 or 4-second time delay, the device restores current when voltage returns to 85 per cent of normal within the time for which it is set. One device can be used with any number of push-button stations for operation of a motor starter from several remote locations. Relay is supplied in NEMA type I general purpose sheet steel enclosure or in NEMA type VII explosionproof cast-iron enclosure for class I group D hazardous locations. Manufacturer: Square D Co., Industrial Controller Div., 4041 N. Richards St., Milwaukee 12, Wis.

For additional information circle MD 7 on Page 157

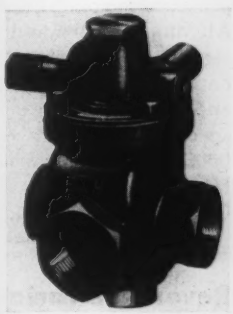
High-Frequency Alternators



Equipped with a low-slip induction motor to keep frequency within plus or minus 0.5 per cent, this single or three phase homopolar inductor unit with electronic exciter regulator provides a voltage regulation of plus or minus 1 per cent. Since it is self-excited through high-vacuum rectifiers, the unit operates independently of line frequency fluctuations. Available in sizes to 10 kw with frequencies to 1500 cycles, it can be used as a power supply for motor drives on high-speed machine tools and instruments as well as electronic gear such as induction heating, radar, etc. The unit can be supplied as self-ventilated or water-cooled. Manufacturer: American Electric Motors Inc., 4811 Telegraph Road, Los Angeles 22, Calif.

For additional information circle MD 8 on Page 157

Time Delay Air Valve

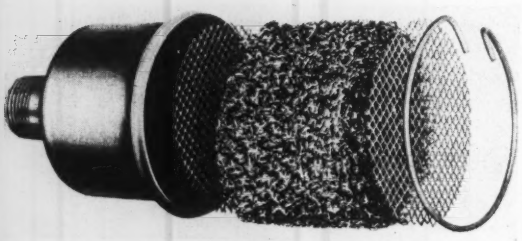


Controlled by regulated air volume, this time-delay valve insures constant repetition of time sequence. The unit is available for use on all Ross in-line operating bodies which range in size from ¼ to 1¼ in. and are furnished in straight-way, three-way, normally open and normally closed models. The valve is especially adaptable for jigs, fixtures, machine tools, and other applications requiring time sequence of two or more operations. Manufacturer: Ross Operating Valve Co., 120 E. Golden Gate Ave., Detroit 3, Mich.

For additional information circle MD 9 on Page 157

Air Cleaner

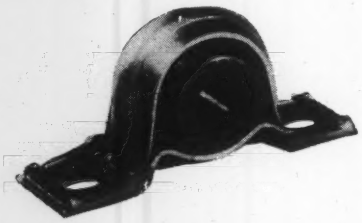
Designed for use where air requirements are not great and where low cost is a factor, Micro-Mesh air cleaner traps dust particles by means of oil-wetted filtering element. Woven to uniform density from single strand of copper ribbon, filtering element is held in place under compression by rigid screen, which in turn is retained in body of cleaner by snap ring. By squeezing snap ring, entire element can be removed. There is no need to remove body of air cleaner for servicing, and it can be permanently affixed to carburator or air intake. Unit operates effi-



ciently at any angle. Cleaner is available in many standard sizes; special sizes can be built to specifications. Manufacturer: Donaldson Co., St. Paul, Minn.

For additional information circle MD 10 on Page 157

Self-Aligning Bearings



A cavity filled with sponge iron acting as wick plus exceptionally high porosity of bearing metal insures adequate lubrication for life of the Lubralife pillow block. Both sponge iron section and pores in metal are impregnated with lubricant under pressure so that lubricant forms thin protective coating around shaft without dripping. Alignment is insured by floating ball and socket construction of unit. These bearings are available in both pillow block and flange mountings in ¼, ⅝, ¾ and 1-in. bore sizes. Other sizes can be supplied on special order. Expected life of units is 20,000 to 30,000 hours under normal operating conditions. Manufacturer: Congress Drives Div., Tann Corp., 3750 E. Outer Dr., Detroit 34, Mich.

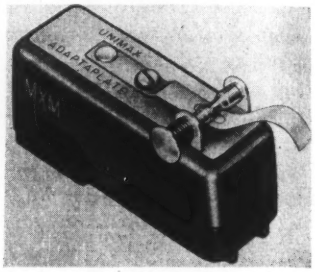
For additional information circle MD 11 on Page 157

Reversible Variable-Speed Drive

Infinite speed variation from 0 to 425 rpm in both forward and reverse at 1750-rpm input speed is possible with model 14R Zero-Max transmission. Reversal of the transmission may be effected while stationary or in motion. Reversal of motor rotation does not change direction of rotation of output shaft. In addition to providing variable speed, the unit is an efficient torque converter with a rating of 10 lb-in. on the output shaft. It can be used for throttle, governor or directional control, drum rotation, camera finding and other uses where reverse control is required. It can also be adapted to installations where repetitive accuracy of setting is needed. Dimensions of the unit are 4¾ x 3½ x 2½ in. Manufacturer: Revco Inc., Dept. MD, Minneapolis, Minn.

For additional information circle MD 12 on Page 157

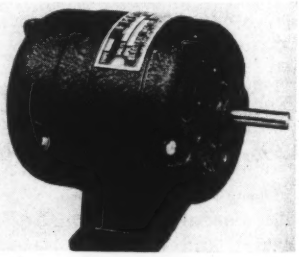
High-Voltage Safety Interlock



An electric circuit can be reclosed manually for testing with no danger of being found 'hot' later by employing safety interlock for high-voltage equipment. This device is provided on an Adaptaplate for standard Unimax snap-acting switches. Conventional leaf-type actuator opens switch contacts when door or access panel of protected enclosure is opened as little as ⅛-in. Pushbutton-operated slide cam is mounted above leaf actuator so that interlock circuit is reclosed when 'cheater' button is pushed. Detent in slide cam engages leaf actuator to keep switch contacts closed while circuit is being worked on. Switch is restored to safety position manually or automatically when door is closed. Manufacturer: W. L. Maxson Corp., Unimax Switch Div., 460 W. 34th St., New York 1, N. Y.

For additional information circle MD 13 on Page 157

Brush Type Fractional-Horsepower Motor

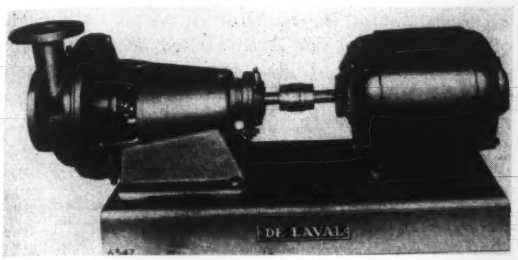


A dynamically balanced, single shaft, fractional-horsepower motor, Model 1100 is rated 1/20-hp intermittent duty and 1/25 - hp continuous duty. The motor can be equipped with any EMC gear reduction unit, a large number of ratios being available for low output speeds. Model 1100 can also be supplied with an electric governor for constant speed application. Motor case is diecast. Maunfacturer: Electric Motor Corp., Racine, Wis.

For additional information circle MD 14 on Page 157

Process Impeller Pumps

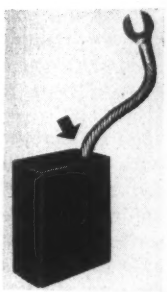
Built in seven sizes, type CP pumps are designed for general service applications in process industries that require handling clear, viscous and corrosive liquids hot or cold, as well as liquids carrying suspended solids. The pumps are furnished with open or closed impellers, which are easily converted, and



with either mechanical seals or conventional packing. Vane characteristics and materials of construction can be selected to suit requirements. To compensate for wear at impeller face, the entire rotor can be adjusted axially by means of an external adjusting screw. Eductor vanes on back of impeller reduce end thrust, relieve stuffing box pressure and keep back of impeller clean when handling liquids with solids in suspension. Manufacturer: De Laval Steam Turbine Co., Trenton 2, N. J.

For additional information circle MD 15 on Page 157

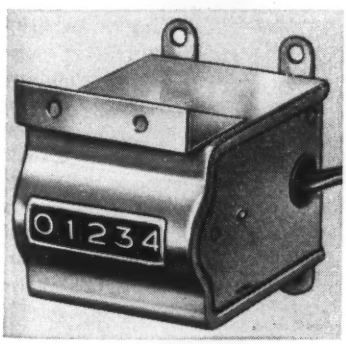
Permanent Shunt Connection



Thorough testing has indicated that this Statite shunt connection for carbon brushes cannot be pulled or jarred loose from brush. It will maintain original low millivolt drop, will not oxidize and is unaffected by extreme operating temperatures. On basis of service performance, it can be classified as permanent type. Manufacturer: U. S. Graphite Co., Saginaw, Mich.

For additional information circle MD 16 on Page 157

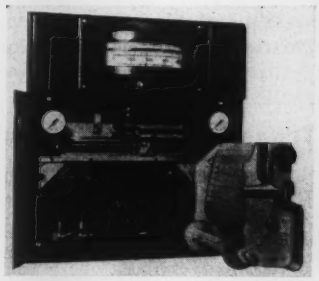
Small Electric Counter



This small Mercury electric counter is intended for mounting on panels and for built-in applications where flush mounting is advantageous. It is completely enclosed in tamperproof metal case with plastic window. Nonresetable, it counts to 100,000 and repeats. Capable of 600 counts per minute, counter can be furnished for operation on 6, 24, 30, 115 or 230-v 60-cycle ac or 6, 24, 30 or 115-v dc. It measures 2⅜ x 1¾ x 2¼ in. Manufacturer: Production Instrument Co., 702-08 W. Jackson Blvd., Chicago 6, Ill.

For additional information circle MD 17 on Page 157

Strip Chart Recorder

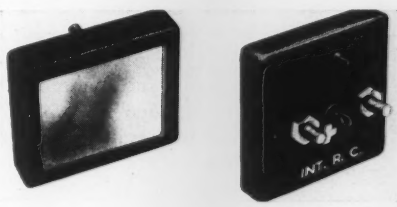


Temperature, speed, flow, pressure, voltage, current and other variables can be measured easily by Pneumatic Capacilog strip recorder. Control function is performed by air through electronic link which operates diaphragm motors connected to valves, dampers, levers and pistons. Self-contained, the unit has only two external air connections. Manufacturer: Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill.

For additional information circle MD 18 on Page 157

Selenium Photoelectric Cell

This hermetically sealed self-generating type selenium photoelectric cell has average current sensitivity of 600 ma at illumination of 100 ft-candles with 100-ohm external circuit resistance. It can be used in conjunction with testing, counting, control and smoke detection operations and is not affected by adverse atmospheric conditions or salt spray. The extruded brass case employs a glass-to-metal alloy for



hermetic sealing. Case measures 2-in. square by 7/16-in. thick with active cell area of approximately 2.25 sq in. Positive contact is made by center lug and negative terminal is located ¾-in. from positive one. Two insulated mounting screws are located ½-in. on either side of positive contacts. Manufacturer: International Rectifier Corp., 6809 S. Victoria Ave., Los Angeles 43, Calif.

For additional information circle MD 19 on Page 157

Mineral-Filled Phenolic Compound

Durez 15893 mineral-filled phenolic molding compound is suitable for applications where high temperatures are encountered or where fine surfaces, such as in decorative parts, are desired. Properties of the compound are: Specific gravity, 1.57; water absorption, 0.20±0.01 per cent; flexural strength, 0.26 ft-lb per in., min.; no distortion under heat up to 340 F, min. High frequency preheating characteristics are similar to those of other mineral-filled materials. Surface appearance and strength are not

affected by constant or intermittent exposure to high temperatures. The compound can be molded by compression or plunger methods. Manufacturer: Durez Plastics & Chemical Inc., North Tonawanda, N. Y.

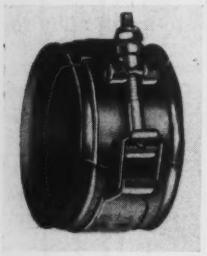
For additional information circle MD 20 on Page 157

Translucent Plastic Tubing

Carbon C plastic tubing is corrosion resistant, lightweight, flexible and contains no pigments that might be absorbed by certain chemicals. Applications include use in air conditioning and refrigeration equipment, instruments and radiant heating systems, transmission of highly corrosive gases and vapors and food processing equipment. Tubing withstands temperatures from −50 to 140 F. Sizes from ¼ to 1 in. are furnished from stock in 100-ft coils, and coils of up to 500 ft can be supplied on order. Manufacturer: Carter Products Corp., 10303 Meech Ave., Cleveland 5, O.

For additional information circle MD 21 on Page 157

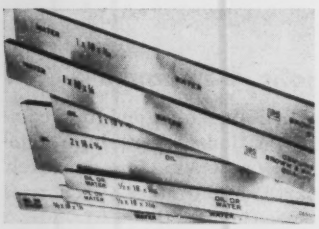
Channel Band Coupling



Available in sizes ranging from 1 to 4 in., these channel band couplings can be obtained with either quick coupler or T-bolt type latch for joining beaded tubes and ducts. Sleeve liners are supplied in two types: Silicone impregnated Fiberglas for temperature applications up to 500 F, and oil and gas resistant synthetic rubber for refueling joints at pressures up to 400 psi. Couplings will compensate for small amount of misalignment of tubing as well as manufacturing tolerances. Manufacturer: Marman Products Co., Inglewood, Calif.

For additional information circle MD 22 on Page 157

Ground Tool Steel

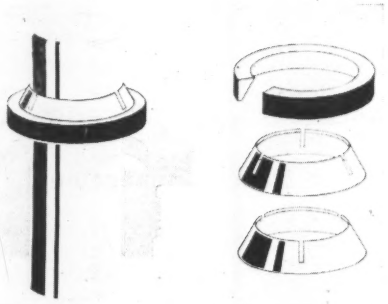


Sixteen thicknesses in widths up to 6 in., all 18-in. long, are obtainable in this tool steel which is accurately ground to thickness tolerance of 0.001-in. After quenching the steels develop a hardness of approximately 64-66 Rockwell C and can be used for the manufacture of tooling and machine parts. All sizes 3/16-in. and under can be hardened in both oil and water. Thicknesses from 7/32 to 1-in. are available for hardening in either oil or water only. Pieces have smooth edges and are marked as to type at intervals throughout their entire length. They are packaged in individual envelopes colored for quick identification. Manufacturer: Brown & Sharpe Mfg. Co., Providence 1, R. I.

For additional information circle MD 23 on Page 157

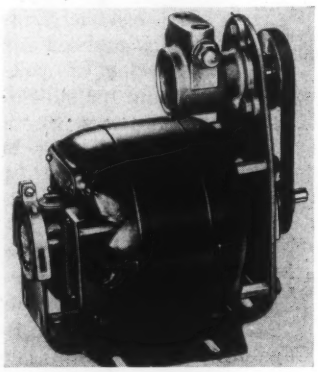
Metallic Rod Wiper

Hydraulic and pneumatic cylinder packings and rods are permanently protected from falling or flying debris by Seal-Guard metallic rod wiper. Two flexible bronze rings mounted in synthetic rubber lift harmful substances completely off rod by means of their knife-edge conical surfaces. Device is self- adjusting through action of rubber on staggered scraper rings, and maintains close contact with rod at all times. Obtainable in wide range of rod sizes, wiper can also be used to protect machine spindles, guide bushings, retracting dowels, or other close-fitting moving parts. Manufacturer: Hydraulic Accessories Co., Dept. 123, Detroit 26, Mich.



For additional information circle MD 24 on Page 157

Vane Type Positive-Displacement Pump



Having a capacity of 60 gph, this vane-type positive displacement pump operates at pressures up to 200 psi and will handle variety of corrosive liquids. Producing a vacuum of 26 in. of mercury, pump incorporates relief valve which can be set for any desired pressure. Fluid can flow directly through pump when it's not in operation. Unit operates quietly without pulsation and can be run dry without damage. With belt driven model, any standard ¼-hp electric motor can be used. Pump can be mounted to left or right or vertically on top of motor, or direct-

connected to any standard motor or machine drive shaft. Unit covers area of 6 x 9 in. To disassemble pump, two snap-rings are removed. Manufacturer: Procon Pump & Engineering Co., 1600 E. Eight Mile Rd., Detroit 3, Mich.

For additional information circle MD 25 on Page 157

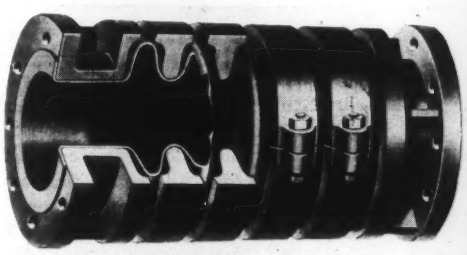
Gravity Feed Oiler

Measured amount of lubricant is supplied automatically by this gravity feed oiler to plain, stationary and antifriction bearings. Ratchet control mechanism is instantly adjustable to feed any number of drops per minute, and spring device locks adjustment into position to avoid dangers of changing rate of feed. Protective cap shields mechanism from dust and dirt and possible damage or distortion when device is cleaned or wiped. Dual purpose vent relieves suction and back pressures caused by tight bearings or high speeds and also provides overflow when feed is set too fast. Oiler is available in 1, 2, 4 and 8-oz capacities with ⅛, ¼ and ⅜-in. pipe thread. Oil supply is clearly visible through shatterproof reinforced plastic reservoir. Manufacturer: Trico Fuse Mfg. Co., 2948 N. Fifth St., Milwaukee 12, Wis.

For additional information circle MD 26 on Page 157

Corrugated Expansion Joint

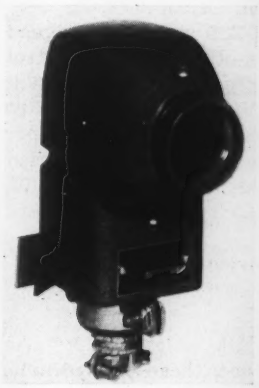
Expansion and contraction caused by temperature change can be controlled by these packless in-line corrugated expansion joints. Two types are available: Controlled-flexing joints with control rings for high pressure use and free-flexing joints without control rings for low pressure use. They operate at pressures to 300 psi and temperatures to 1600 F. Joints of copper, stainless steel or other alloys are



available in sizes from 3 to 24-in. ID. They are fabricated with single or multiple corrugations, with or without control rings, and with either flanged or welding ends. Units with stainless steel inner liners, tie rods and special flanges for individual installation requirements are available. Manufacturer: Chicago Metal Hose Corp., Expansion Joint Div., 1306 S. Third Ave., Maywood, Ill.

For additional information circle MD 27 on Page 157

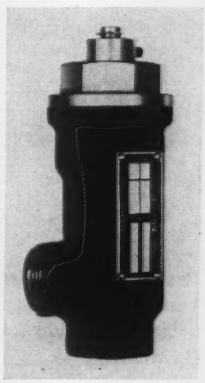
Photoelectric Units



Applicable with photoelectric relays for counting, signaling, limiting, controlling or protecting, standard units consist of complete range of improved light sources and phototube holders. General-purpose light sources have snap-on covers to facilitate replacement of prefocused lamps. Phototube holder is furnished complete with phototube, lens, masks and 9-ft connecting cable. Mounting clamp and standard pipe thread for ½-in. conduit are provided for mounting convenience. Phototube holders and 3-in. lens light source are weather-resistant and dustproof. Manufacturer: General Electric Co., Schenectady 5, N. Y.

For additional information circle MD 28 on Page 157

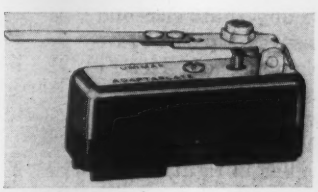
Hydraulic Relief Valve



Meeting requirements of Specification AN-V-lb for Army and Navy aeronautical use, this cartridge type hydraulic relief valve offers design possibilities for industry where precision hydraulic controls are required. Providing high-volume flow at pressures from 100 to 5000 psi, it opens and closes within 7 per cent differential, and even smaller operating differentials can be supplied if required. Full load shocks and surges do not disturb valve's 'in balance' operation at any time. Valve operates quietly and is free from squeal and chatter. Manufacturer: Hydraulics Div., Pantex Mfg. Corp., Pawtucket, R. I.

For additional information circle MD 29 on Page 157

Snap-Acting Precision Switch



Simple screw adjustment of the leaf actuator of type MXT-1-Z131 snap-acting precision switch allows operating point to be set at exact position for desired action. This single micrometer adjustment compensates for cumulative effect of tolerance variations in mass-produced assemblies. Turning Allenhead screw on hinged arm of leaf Adaptaplate raises

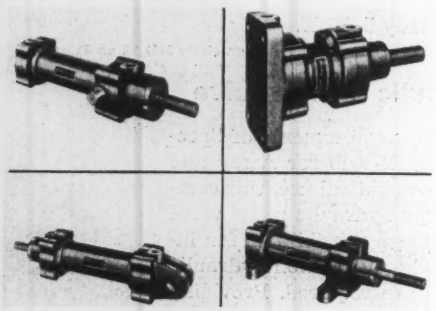
or lowers operating point through range of 3/8-in. Adjusting screw is friction-held by Elastic stop nut to prevent accidental change in adjustment.

Also available is type MX-1-Z25 which is designed to permit close setting of on-off cycles in control circuits. It gives a variable differential motion which can be fixed anywhere within a range of 0.0005 to 0.008-in. Adjustment that raises or lowers upper contact inside switch is made by means of knurled knob on top of the switch body. Manufacturer: W. L. Maxson Corp., Unimax Switch Div., 460 W. 34th St., New York 1, N. Y.

For additional information circle MD 30 on Page 157

Oil Hydraulic Cylinders

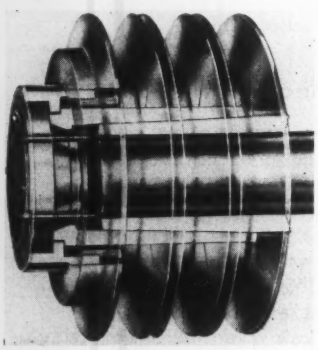
Designed for industrial service, these oil hydraulic cylinders can be obtained in twelve standard mountings ranging from 1 to 8 in. They are equipped with either standard or heavy-duty rods and with or without cushions. Features include improved cylinder



head seals, multiple piping connection positions, self-adjusting packings and adjustable hydraulic cushions. Design follows practice recommended by JIC Hydraulic Standards for Industrial Equipment. Manufacturer: Vickers Inc., 1430 Oakman Blvd., Detroit 32, Mich.

For additional information circle MD 31 on Page 157

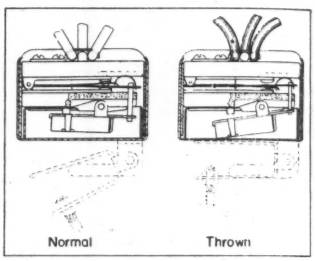
Adjustable-Pitch Sheave



Double-taper hub feature of this adjustable-diameter V-belt sheave adapts it to any shaft size and assures positive clamping on shaft and quick break-away when dismounting. When bushing is pulled in tight to lock it on shaft, wedging action expands and locks taper sleeve against flanges and hub. Simultaneous movement of all flanges when settings are changed maintains V-belt alignment. Because there are no clearances when sheave is locked and operating, there can be no peening or fretting of metal parts. Sheave is available in sizes for most standard and wide-range adjustable-diameter drives. Manufacturer: American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa.

For additional information circle MD 32 on Page 157

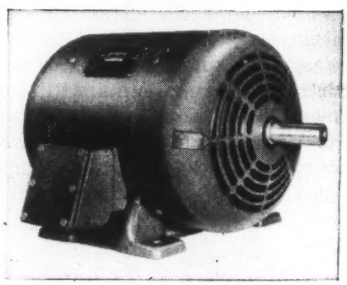
Magnetic Proximity Switch



Enclosed in a metal canister, this magnetic proximity switch employs a toggle type stack switch actuated by Alnico permanent magnet which in turn is actuated by an armature of magnetic material. The snap-action switch is single-pole double-throw and is attached to the magnet by a nonconductive link. Types available are rated 10 amp 110-volts ac and will withstand temperatures of 175, 250 or 400 F, depending upon method of sealing and pigtail insulation. Switch can also be furnished with 3-in. conduit housing. Manufacturer: Jo-Bell Products Co., 4840 S. St. Louis Ave., Chicago, Ill.

For additional information circle MD 33 on Page 157

Chemical-Proof Motors



For protection against corrosive fumes and liquids, type CSP Life-Line motors employ bronze split-hub clamp type blowers. Rotating neoprene slingers on shafts between rear brackets and hoods prevent entrance of dirt or liquids into prelubricated bearing housings. Stator windings are double-dipped and baked in thermoset varnish. Gasketed conduit box can be rotated to meet installation requirements. Frames, brackets, hoods and other exposed parts are fully protected by acid-alkali cleaning, hot-water rinse and several coats of baked enamel, thermoset varnish and lacquer. Manufacturer: Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

For additional information circle MD 34 on Page 157

Welded Stainless Steel Tube

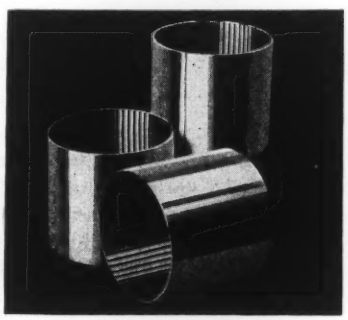
In addition to free-machining and corrosion-resistant qualities, type 303 welded stainless steel tubing has non-galling properties that simplify disassembly

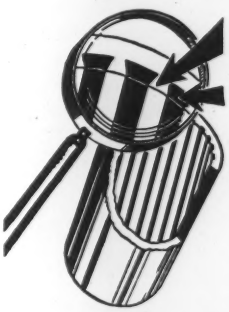
Graphited Bronze Bearings

GRAPHITED SLEEVE TYPE BEARINGS were developed primarily for applications where lubrication is difficult, likely to be neglected and where the speed of the shaft is too slow to sustain an oil film. They are also used in some applications where ordinary lubricants might damage goods or food products in process and where temperatures are too high for oil or grease.

There are three fundamental types available: cast bronze with serrated grooves, cast bronze with graphite plugs and bronze sheet metal with serrated, rectangular or diamond shape indentions.

In the cast bronze serrated type, minute, dovetailed grooves are cut into the bearing surface at a 7 degree lead. Graphite is then compressed into these serrations and remains permanently in place. This type provides from 40 to 45% graphite contact with the shaft which increases slightly with wear.





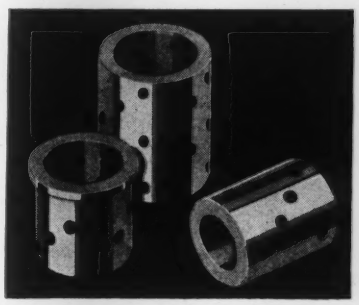
··· Serrated type graphite bearing. Note the 7° lead and the dovetail shape of the serrations.

Plug type graphited bearings are produced by drilling holes of a suitable size in a cast bronze bearing on a staggered pattern through the wall. Stick graphite is then forced into these holes and remains permanently in place.

In some applications, ordinary oil grooves or combinations of oil grooves can serve as recesses to hold the graphite. It is also possible to compress graphite into grooving on the flange of cast bronze bearings when the application requires it.

The first step in producing bronze sheet metal graphited bearings is to cut serrations longitudinally into coiled strips of sheet bronze. The graphite is then forced into these serrations by a high pressure, patented process and baked under a carefully controlled temperature. The strip material is then blanked and formed into cylindrical shapes. In producing the cylindrical shape the serrations automatically become dovetailed which holds the graphite permanently in place.

Cast graphited bearings can be reamed in place, a maximum of 0.005 stock being removed. Sheet metal bearings *must* be burnished in place. The graphite used in Johnson bearings is not soluble in water, oil or gasoline. An occasional application of oil or grease where permissible will greatly increase the life of the bearing and lower the coefficient of friction. Cast graphited bearings are recommended for applications having slow speeds and minimum loads. For intermittent service or oscillating motion we recommend sheet metal with graphite. Quantity is a factor also and in large production runs of any given size, sheet metal is surprisingly low in cost.



Limiting Factors For Successful Performance

1-Speed—Load Factors:

(a) For constant running shafts—PV=18,000# in (min.) sq. in. proj. area.

(b) For constant running shafts (with supplementary lubrication) PV=120,000# in (min.) sq. in.

(c) For Oscillating shafts—PV=60,000# in (min.) sq. in.

(d) Intermittent service—PV=120,000# to 250,000# in (min.) sq. in. (use safety factor)

2-Bearing Pressures:

(a) All graphite jobs (without additional lubrication) 40 to 50# sq. in. (for speeds of 30 ft. per min.)

(b) With supplementary lubrication 350# sq. in.

3-Temperatures:

(a) Standard graphited bushings—Satisfactory up to 250° F. 275° F. (Using conventional leaded bronzes and serrated type.)

(b) For temperatures up to 400° F. Conventional leaded bronzes with graphite plugs.

(c) For temperatures—Up to 1000° F. Special lead bronze alloys with graphite plugs. At higher loads, oil should be used in conjunction with the graphite plugs for higher efficiency.

4-Running Clearances:

(a) Constant running shafts—50% higher than standard.

(b) Oscillating shaft—Standard allowance can be used.

5-Wall Thickness:

Minimum thick.
1/16" for O.D. up to 1".
Minimum thick. Serrated type
3/32" for O.D. over 1".
Max. wall thick.—Optional to designer. For plug type graphite—wall to be same as diameter of graphite plug—1/8 min.

6- Graphited bushings should be recommended for speeds less than 30 ft. per min. for at such low speeds it is impossible to develop film pressure necessary to prevent metallic contact.

7-Stock Allowance for finishing

(a) It is necessary to finish bushing in assembly. Reaming stock allowance of not more than 0.005 should be allowed for cast bronze graphited.

(b) At least 0.004 stock for burnishing sheet metal graphited.

Ledaloyl Bearings

While graphited bearings are sometimes referred to as "Self-Lubricating" Johnson Bronze produces another type by powder metallurgy known as *Ledaloyl*. This bearing is low in cost, high in efficiency and holds up to 35% oil by volume. It is particularly economical when produced as a self-aligning, flanged or other odd shaped part as there is no machining required. Write for complete details.

●

This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze

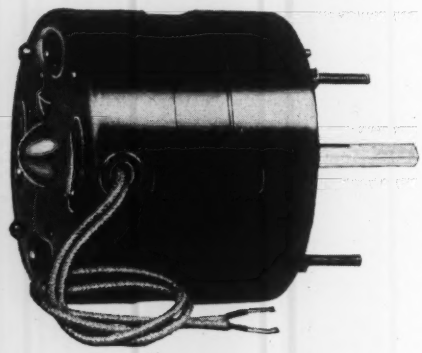
SLEEVE BEARING HEADQUARTERS
525 S. MILL ST. • NEW CASTLE, PENNA.

of parts and minimize scratching in moving parts. Tube is recommended for parts that must be fabricated by threading, turning, reaming and drilling and for intricate parts where smooth surfaces are required. Material is not recommended for cold working applications. Tubing is available in rounds or shapes from ¼ to 4½-in. OD and in all standard wall thicknesses. Manufacturer: Carpenter Steel Co., Alloy Tube Div., Union, N. J.

For additional information circle MD 35 on Page 157

Fractional-Horsepower Motor

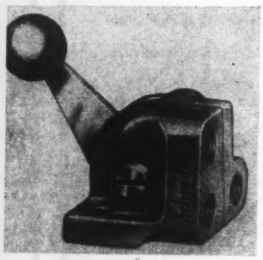
Obtainable in ratings from 1/10 to 1/60-hp at 1550 rpm on 60 cycles, these four-pole shaded-pole induction motors are supplied in three styles of frames. Drawn steel housing with self-aligning bearings is offered for general purpose applications. Die-cast



housing is available with ball or sleeve bearings. Third style employs unit bearing construction and is totally enclosed with sealed lifetime lubrication. Manufacturer: Russell Electric Co., 4501 S. Western Blvd., Chicago 9, Ill.

For additional information circle MD 36 on Page 157

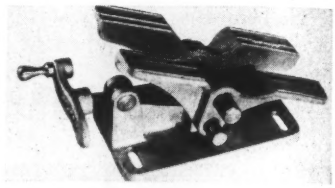
Small Air Control Valves



For use with single and double - acting pneumatic cylinders, these two, three and four-way bantam size sliding seal control valves can be obtained for hand, foot, knee or mechanical actuation. They are forged brass; one steel bolt holds two-piece body and internal parts in place. Body dimensions are 1⅝ x 1 11/16 in. Although ⅛-in. ports make them especially suitable for use with small bore cylinders, valves can be used on short-stroke cylinders having bores up to 3½ in. Manufacturer: Scovill Mfg. Co., A. Schrader's Son Div., 470 Vanderbilt Ave., Brooklyn 17, N. Y.

For additional information circle MD 37 on Page 157

Tilting Motor Base



Intended for use with fractional-horsepower electric motors, this compact tilting motor base weighs only 10 lb and has reversible mounting brackets for versatility of motor installation. Convenient handle provides effortless adjustment of motor to desired position. Manufacturer: Gerbing Mfg. Co., 650 W. Washington Blvd., Chicago 6, Ill.

For additional information circle MD 33 on Page 157

Front-Operated Safety Switch

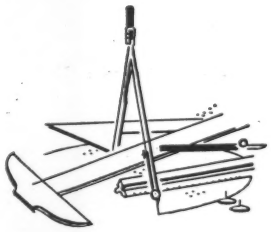
To open cover of type A safety switch, front-operated handle must be turned to "cover open" position, requiring deliberate action by operator to expose switch mechanism. Switch handle can be locked with three padlocks in either open or closed position. For further safety, each blade on 250-v switch has an arc muffler; switches rated over 250 v have Noark Rolarc snuffers with two arc-resisting rollers which snap together to extinguish arcs instantly. The operating cross-bars of the switch are located beneath visible blades. This construction forces contacting blades open, safeguarding operator. The switch has only two joints to each blade, and fuses are held under pressure to minimize contact resistance and insure cool operation. Individual poles of switch are of unit block construction, and complete mechanism can be removed for inspection.

Switch is available in 30, 60, and 100-amp capacities for 230-v ac; 250-v dc and 57.5-v ac; 600-v dc, with horsepower ratings maximum allowed by Underwriters' Laboratories. Type C front-operated safety switch with most of above features is also available. Manufacturer: Federal Electric Products Co., Newark 5, N. J.

For additional information circle MD 39 on Page 157

Heavy-Duty Gearshift Drive

Type R3C heavy-duty gearshift drive combines an integrally mounted electric motor with a four-speed transmission having both primary and secondary gear reductions. The drive delivers full-rated horsepower in each of the four primary speeds—4.15, 3.15, 1.85 and 1 to 1. Both constant-torque and constant-horsepower two-speed motors are available. The unit is



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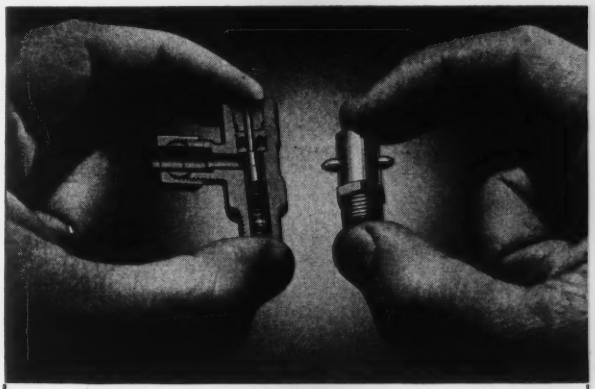
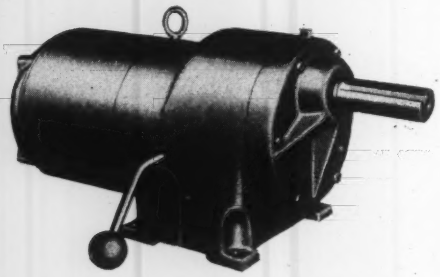


1 Alemite "Midget" System—slightly larger than a pin-type fitting, this Alemite "Midget" measuring valve is readily applicable to all types of heavy, light and precision machinery. Its simple, compact design makes it especially suitable wherever space limitations are encountered. Mounted on or near the bearings, the Alemite "Midget" delivers a measured amount of oil or grease from one central point. Can be installed for either manual or automatic operation.

2 Alemite Single Line System . . . applicable to heavy or light machines, precision machines, outdoor installations. It is a single lubricant line, hydraulically operated system for oil or grease. Valves can be installed on or near each bearing. A measured amount of lubricant is conveyed to each bearing from one central point while machine operates. An indicator signals when job is done. Choice of manual or automatic operation.

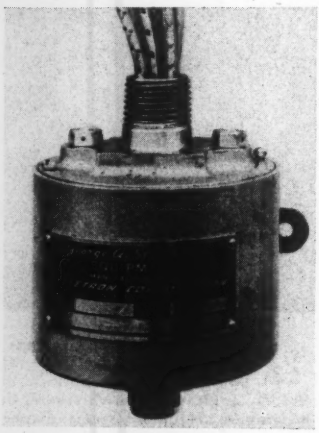
3 Alemite Single Line, Reversing System is ideal where excessive dirt and moisture is a problem. The system is completely enclosed, fully hydraulic. Each valve delivers a large or small metered amount of oil or grease to two bearings. The lubricant flows *progressively* to each bearing while the machine is producing . . . an indicator at the point of introduction signals when lubrication is completed. Designed for manual or automatic operation.



designed to operate on polyphase alternating current power supplies of standard frequencies and voltages below 600. Manufacturer: Lima Electric Motor Co., Dept. AA97, Lima, O.

For additional information circle MD 40 on Page 157

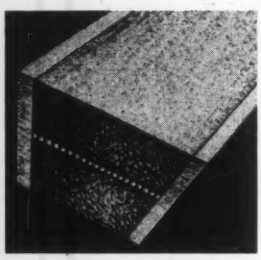
Pressure Actuated Switches



Model 424 Dualtrol switch employs diaphragm sensing element to actuate two single-pole double-throw snap-action switching elements at any two predetermined, independent pressures. Six classes of switches provide adjustable pressure ranges from 2 in. of water to 100 psi, with proof pressures up to 120 psi. Pressure connection is made to ⅛-in. internal thread; electrical connection is through ½-in. conduit connector. Manufacturer: Meletron Corp., 950 N. Highland Ave., Los Angeles 38, Calif.

For additional information circle MD 41 on Page 157

Leather-Rayon Bonded V-Belt

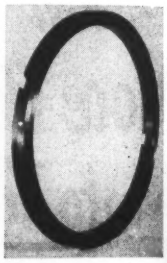


This leather V-belt for single and multiple drives has a built-in row of rayon cords bonded between the leather plies to minimize stretch and thereby preserve belt tension in service. Belts are supplied endless or in rolls which can be spliced endless on the sheaves. A scarfed joint is used and joined with Duxbak waterproof cement. Mechanical fasteners can be employed if desired.

Two tools are supplied for splicing and cementing —E-Z lap cutter and lap press. When installing the belts directly in the grooves, a tension rod and clamp are added to each end of the press clamp to make possible the installation of the belts at any desired tension without dismantling the drive. Manufacturer: Chas. A. Schieren Co., New York, N. Y.

For additional information circle MD 42 on Page 157

Cylinder-Shaft Seal



Consisting of one inner ring and two close fitting outer rings, this three-piece cylinder and shaft seal can be made of noncorrosive material or practically any metal alloy. Step of inner ring is staggered so that, even after much wear, blow-by is kept to minimum. Applications of seal include use on hydraulic hoists and jacks, pumps and machinery. Manufacturer: Auto-Diesel Piston Ring Co., 3145 Superior Ave., Cleveland 14, O.

For additional information circle MD 43 on Page 157

Fast-Drying Synthetic Enamel

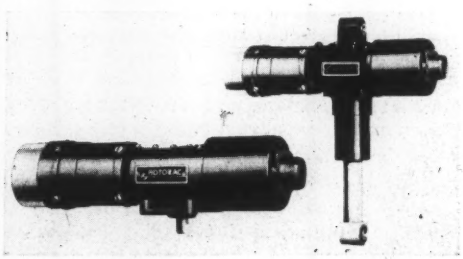
Providing the hardness of a baked-on finish, Base Y 2054 synthetic protective coating air-dries as fast as lacquer. Products finished with this enamel can be handled and stacked within 15 minutes and packed within 4 hours. Hard, tough surface film is resistant to alkalies, fats, grease and smoke. The enamel is equally effective on wood, metal or fiber products, and can be polished to a hard gloss. It has good gloss and color retention under high humidity conditions. Manufacturer: United Lacquer Mfg. Corp., 1001 W. Elizabeth Ave., Linden, N. J.

For additional information circle MD 44 on Page 157

Rotary & Linear Actuators

In addition to low-voltage direct-current operation for which they were originally designed, Rotorac and Lineator electric rotary and linear actuators (MD Jan., '50) have been modified to operate on 110-v 60-cycle single-phase alternating current. Installation, dimensions and performance of new models are substantially same as direct-current models. Manufacturer: Airborne Accessories Corp., 25 Montgomery St., Hillside 5, N. J.

For additional information circle MD 45 on Page 157



Effective sealing of metal-to-metal joints

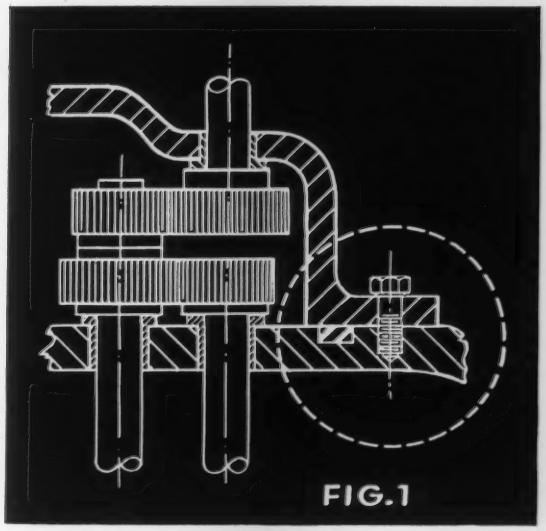


FIG. 1

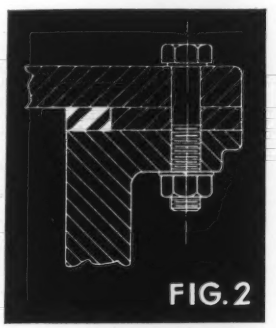


FIG. 2

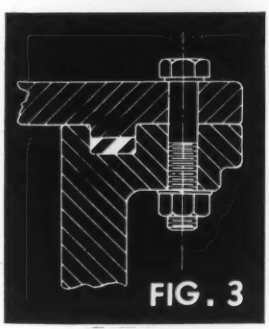


FIG. 3

Effective sealing of metal-to-metal joints requires: (1) complete filling of the recessed gasket channel to provide maximum contact area between gasket and mating flange and (2) correct gasket compression to prevent seepage of the sealed medium or crushing of the gasket.

Both of these requirements can be met with gaskets cut from truly compressible materials like Armstrong's Cork-and-Rubber Compositions.

To fill the channel completely, cork-and-rubber gaskets are cut to full channel width and, depending on compressibility, from 1.25 to 1.5 times channel depth. Because these gaskets actually decrease in volume under load, they do not require relief for sideflow or excessively close gasket and metal tolerances.

Correct gasket compression is also assured with the right cork-and-rubber composition. Each cork-and-rubber material combines controlled amounts of truly compressible cork and non-compressible synthetic rubber. Hence it provides a predetermined degree of compressibility to handle the desired range of flange pressures.

Typical of the metal-to-metal sealing jobs done by cork-and-rubber is the instrument flange in figure 1. Completely confined, the cork-and-rubber prevents seepage of the lubricating oil and permits perfect alignment of the gears.

In figure 2, flat flanges were adapted to metal-to-metal sealing by inserting an annular shim. Here, cork-and-rubber compresses to form a tight seal without tending to flow out of position.

The high-pressure flange shown in figure 3 utilizes a stop to prevent blowouts. By completely filling the confined volume, cork-and-rubber insures a tight seal.

Effective sealing of metal-to-metal joints is but one type of job handled by Armstrong's Cork-and-Rubber Compositions. Your Armstrong representative will gladly help you apply these versatile materials to your application.

Send for this Gasket Handbook

You'll find useful application and specification data in the revised 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date information on straight synthetic rubber, cork-and-synthetic-rubber, and cork composition gasket and sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries.

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ENGINEERING DEPARTMENT
EQUIPMENT

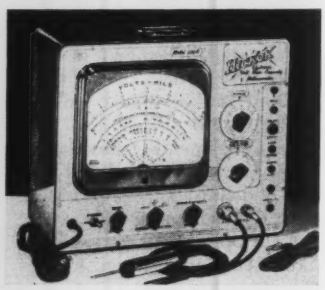
For additional information on this new equipment see Page 157

All-Metal Measuring Scales

Low coefficient of expansion of these all-metal triangular and flat measuring scales insures permanent retention of accuracy. They are engine-engraved with needle-sharp graduations in black against white surface background. Surfaces of triangular scales form inverted-V to bring fine measuring edges of scale down to paper without flat surfaces touching work. Models B-160 Architects' and B-161 Engineers' scales are 12-in. long and weigh approximately 4 oz. Flat scales are available in 12 and 6-in. lengths with standard scale graduations on regular two-bevel and opposite two-bevel bodies. Manufacturer: Cal-Pan Corp., Alhambra, Calif.

For additional information circle MD 46 on Page 157

Volt-Ohm-Capacity Milliammeter

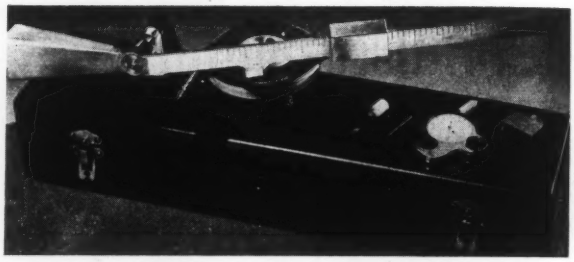


Model 209-A electronic volt-ohm-capacity milliammeter is designed for increased speed, range and accuracy of readings. Operating on 115-volt ac, the instrument measures resistance as low as 0.1-ohm and capacitance of 1 mmf. Peak-to-peak voltage measurements can be made, a zero-center direct-current scale increasing the accuracy. The alternating current range is 1200 volts. Incorporating a 9-in. meter scale, the instrument measures 13¼ by 16¼ by 7 in. and weighs 18½ lb. Low-capacity high-frequency probes, all test leads and a portable steel carrying case are supplied. Manufacturer: Hickok Electrical Instrument Co., 10545 Dupont Ave., Cleveland 8, O.

For additional information circle MD 47 on Page 157

Shear Hardness Tester

This Model 139 shear hardness and diamond scratch tester accurately measures quality of plastic materials and the ability of plastic coated surfaces to resist scratches, digs, scrapes and similar physical damage not classed as normal wear. Both tests are performed with a finely balanced scale beam calibrated in grams. To this is attached an S-20 or S-30

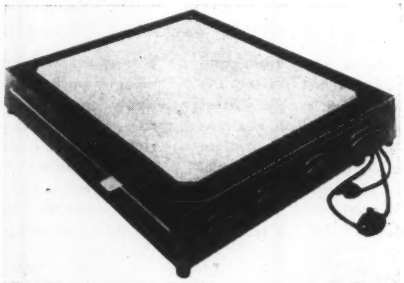


precision-ground shear contour tool or 139-55 diamond point scratch tool. Sliding weight provides adjustment in load from 0 to 500 grams, and extra calibrated weight is furnished to increase load capacity to 1000 grams. Scale beam is pivoted on precision ball bearings. Gage block can be raised or lowered to correspond with specimen thickness, thus maintaining scale beam in level position whether specimen is thin plate or up to ¼-in. thick. Instrument is housed in walnut finished case. Manufacturer: Taber Instrument Corp., 145 Goundry St., North Tonawanda, N. Y.

For additional information circle MD 48 on Page 157

Portable Tracing Board

Having sandblasted glass surface for even light distribution, this portable all-steel tracing board incorporates built-in baked white enamel reflector. Tracing surface is 16 x 20 in. Unit can be used flat



or at incline, and is equipped with two 15-w movable fluorescent lamps, switch and extra long cord. Rubber feet and Underwriters' Laboratories listed electrical parts are used. Finish is hard baked gray hammertone enamel. Manufacturer: Stacor Equipment Corp., 1887 Atlantic Ave., Brooklyn 33, N. Y.

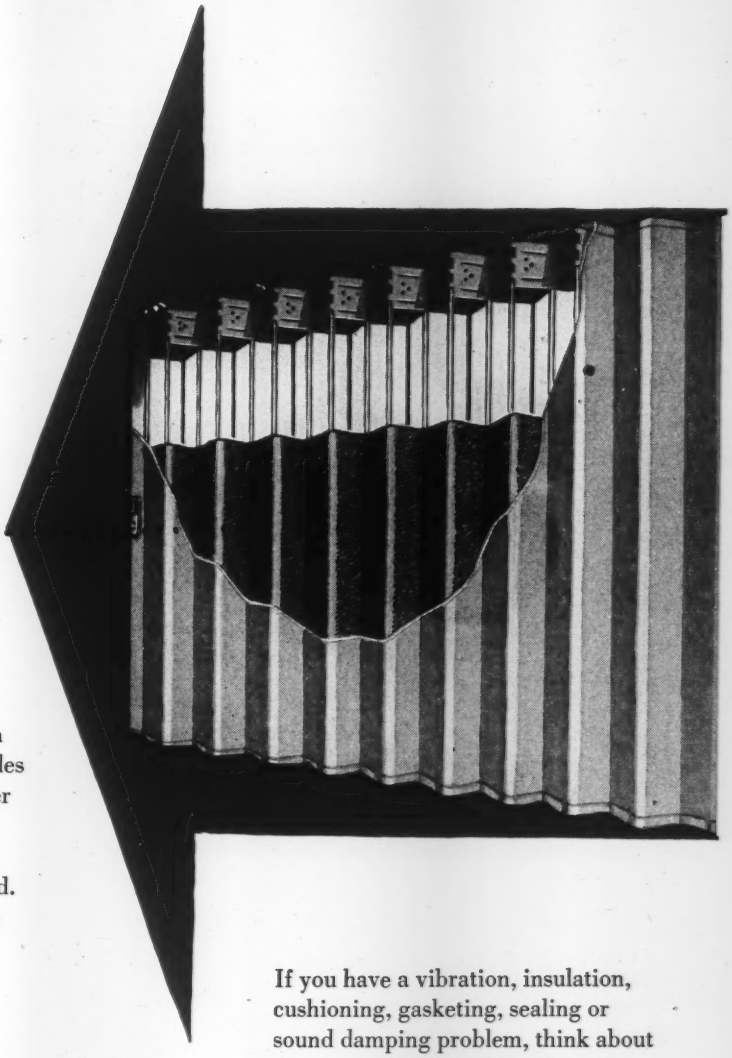
For additional information circle MD 49 on Page 157

To an imaginative design engineer...

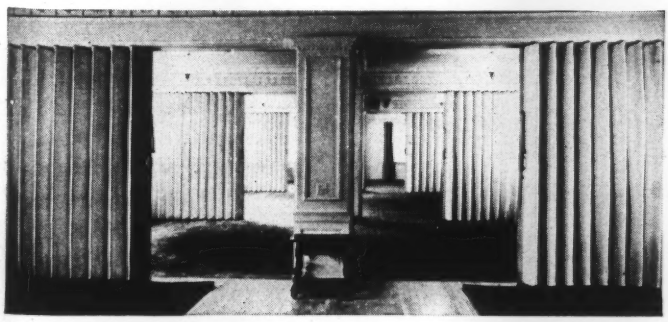
Spongex®

cellular rubber

sound insulates Modernfold Doors.....



New Castle Products make the Modernfold accordion-like partition and closure which temporarily divides large rooms into two or more smaller ones. A sound retarding lining for installation in schoolrooms, offices and hotel banquet rooms was needed. In addition to deadening sound, the lining had to be flexible, durable, lightweight, small in bulk, free of dust and dirt, and economical. Spongex cellular rubber, in sheet form, answered their every need.



If you have a vibration, insulation, cushioning, gasketing, sealing or sound damping problem, think about *Spongex*. Cellular rubber does not become a "product" until you make it one in *your* application. We welcome new problems.

Technical Bulletin on Sponge Rubber available upon request.

The World's Largest Specialists in Cellular Rubber

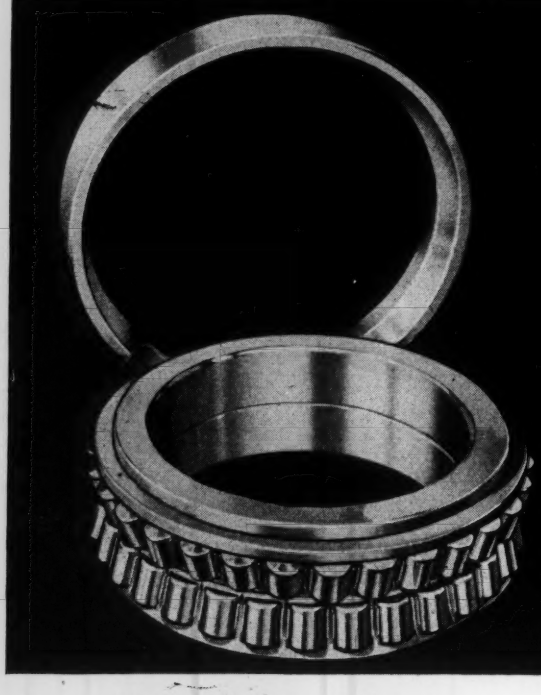
SHEETS • CORDS • TUBING • STRIPS • MOLDED OR DIE-CUT SHAPES AND FORMS.

THE SPONGE RUBBER PRODUCTS COMPANY

300 Derby Place, Shelton, Conn.

Contact KAYDON *of Muskegon*

FOR ALL TYPES OF BALL AND ROLLER BEARINGS 4" BORE TO 120" OUTSIDE DIAMETER



BIG PRECISION GRINDER

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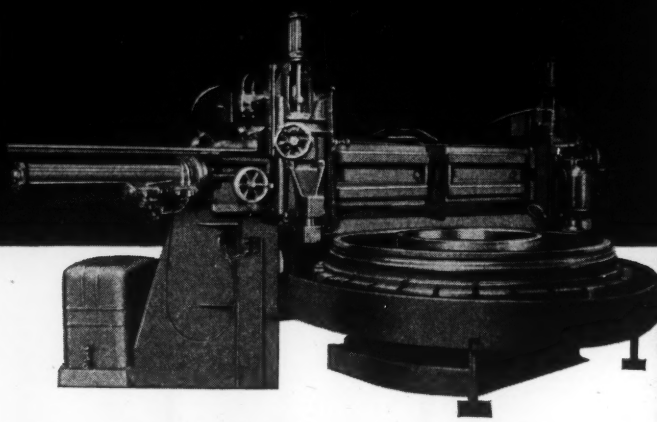

KAYDON Double Row Taper Roller Bearing, 34.000" x 42.250" x 7.375", permits smooth, precision operation of the table spindle on the big 120" capacity double-head, heavy-duty super precision grinder shown at right.

THIS double head grinder permitted production of super precision accuracy in Naval gun mounts. It was designed to produce work of an angular accuracy of less than one-half thousandth (.0005") in 72", in flatness, squareness, concentricity, roundness and taper, and permitted interchangeability of gun mount parts which formerly were tediously hand scraped. Parts produced in regular production to an accuracy of .0002".

We believe this to be the world's largest, super precision industrial grinder, 26 of which were manufactured.

In heavy oil field machinery, ponderous steel-mill equipment, complicated paper-mill units . . . in rugged road-building machines, excavators, hoists, crushers . . . powerful bending machines, production units, and other industrial equipment . . . KAYDON bearings are improving performance and lengthening service-life. Look to KAYDON, Standard or Special, for the better bearing service your equipment deserves.

* * * *

Counsel in confidence with KAYDON. Capacity now available for all sizes and types of KAYDON bearings . . . and for atmospheric controlled heat treating, precision heat treating, salt-bath and sub-zero conditioning and treatment, microscopy, physical testing and metallurgical laboratory services.

KAYDON *Types of Standard or Special Bearings:*
Spherical Roller • Taper Roller
Ball Radial • Ball Thrust
Roller Radial • Roller Thrust

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

72. Industrial Plastic

Westinghouse Electric Corp.—36-page illustrated booklet B-3184-D tabulates grades and forms in which Micarta plastic is supplied, together with chemical, mechanical and electrical properties of each. Standard shapes and sizes are listed and available finishes described.

76. Vibratory Feeders

Syntron Co.—16-page illustrated bulletin "Special Vibratory Feeders" describes Vibra-Flow furnaces, infrared drying and other types of vibratory feeders as well as conveyors. These units provide controlled yet adjustable rate of flow.

78. Corrosion-Resistant Alloys

Haynes Stellite Div., Union Carbide & Carbon Corp.—40-page illustrated booklet "Haynes High-Strength, Nickel-Base, Corrosion-Resistant Alloys" covers general characteristics of four alloys, their resistance to corrosive media, physical and mechanical properties, available forms and fabrication procedures.

79. Shock-Mounted Instruments

Marion Electrical Instrument Co.—12-page illustrated circular "Marion Ruggedized Electrical Indicating Instruments" outlines engineering and development work that has produced shockproof panel instruments. Hermetically sealed meters withstand all types of weather as well as severe service conditions.

77. Heat Treated Alloy Steels

Joseph T. Ryerson & Son, Inc.—4-page bulletin "Rychrome & Nikrome 'M' " gives engineering data on two high performance alloy steels supplied in heat treated condition ready to use. They are suitable for heavy duty axles and shafts, gears and pinions, studs and bolts and similar applications.

75. Air Circulators

Emerson Electric Mfg. Co.—8-page illustrated catalog X6558 contains practical suggestions on selection and installation of air circulators, details of design and construction, specifications and performance data.

74. Combination Sheaves

Speed Selector Inc.—4-page illustrated bulletin No. 25 depicts Speed Selector variable speed combination sheaves in 3, 4, 5, 6, 7 and 8-in. sizes for transmitting 1/15 to 7½-hp. Sheaves permit unusually large speed variation and wide control with single V-belt.

80. Bronze Products

American Non-Gran Bronze Co.—16-page illustrated booklet "Our Story in Pictures" shows contract manufacturing facilities for precision machine work, bronze and centrifugal castings and Non-Gran bronze having fibrous nongranular structure.

81. Universal Joints

Gear Grinding Machine Co.—Illustrated leaflet form RZ-1145 deals with Rzeppa constant velocity universal joints. They are available as bell joints capable of 35-degrees deflection and as disk type capable of 18-degrees deflection.

82. Powdered Metal Parts

Wel-Met Co.—4-page illustrated pamphlet No. 103 gives details on 25 powdered metal machine parts such as gears, cams, filters, bearings, washers, magnetic pole pieces, guides, and clutch plates. Powdered metal process is explained, together with its advantages and limitations.

83. Vibration Isolators

Korfund Co.—4-page illustrated folder No. G-102 presents characteristics of spring, rubber and cork types of vibration isolation media. Various types of standard mountings with load ratings from 10 to 50,000 lb per isolator are described.

84. Heavy-Duty Engraver

New Hermes Engraving Machine Corp.—24-page illustrated booklet "New Hermes Engravograph" describes heavy-duty machine for wide variety of engraving, profiling, slotting, and vertical milling operations on plastics, woods and metals. Being tracer guided, it is easy to operate.

85. Journal Bearings

Oragne Roller Bearing Co.—4-page illustrated folder depicts design features of journal roller bearings and shows how each of three component parts can be replaced since they are dimensioned for interchangeability. Diameters, bore and prices are listed also.

86. Cast-Iron Pulleys

Sprout, Waldron & Co.—16-page illustrated bulletin No. 33 presents complete data on cast-iron pulleys available in diameters and face widths to meet most any requirements. They can have single or double arms and solid rim and hub, solid rim and split hub or split rim and split hub.

87. Aluminum Casting Alloy

William F. Jobbins, Inc.—12-page illustrated technical file "Almag 35" lists composition, physical properties, corrosion test data and applications of this aluminum casting alloy. It is available in grades for sand, permanent mold and diecasting and has 38,000 to 44,000 psi tensile strength as cast.

88. Gear Motors

Janette Mfg. Co.—4-page illustrated bulletin describes major features and depicts various types of standard fractional and integral horsepower gear motors available from stock. Basic design of these units centers around worm and combination worm-and-planetary gearing to provide compact low-speed power unit.

89. Expansion Joints

Chicago Metal Hose Corp.—28-page illustrated booklet "Design Guide" presents data to aid in proper selection of size and type of expansion joint necessary to fulfill varying requirements of temperature, pressure and other factors in each individual application.

90. Precision Casting

Austenal Laboratories, Inc., Microcast Div.—16-page illustrated booklet "New Horizons with Microcastings" relates development of Microcast precision investment casting process for casting of nonmachinable cobalt-chromium-molybdenum alloy with melting temperature in excess of 2500° F. Included are many applications of precision castings, specifications and step-by-step explanation of process.

91. Seamless Copper Tubing

Penn Brass & Copper Co.—8-page illustrated folder "Seamless Copper Tubing from a Test Tube" discusses advantages of nonferrous tubing which is available ranging from ⅛ to 1⅛ in. OD. Also described are Form-a-Gage height gage with double flare plate and Papco tube flaring tool.

92. Paint Vehicles

Goodyear Tire & Rubber Co.—Technical guide No. 517 deals with use of Pliolite S-5 resin in exterior and concrete paints, and bulletin No. C102 discusses Chemigum 101 synthetic latex for use as vehicle in interior wall finishes which makes possible use of water as thinner.

93. Electronic Tile Sorter

Electronic Associates, Inc.—Illustrated leaflet on model 203 tile sorter tells how this machine detects invisible air pockets in tile at adjustable speeds up to 600 per minute.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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94. Selector Switch

Arrow-Hart & Hegeman Electric Co.—8-page illustrated engineering data folder and target sheet aid electrical engineers in application of Push-Pull-Selector switch. Explained in detail is manner in which this switch provides single master control that will serve from 8 to 16 operations. Target sheet is designed to aid in plotting electrical control requirements.

95. Technical Ceramics

American Lava Corp.—4-page folder chart gives mechanical and electrical properties of AlSiMag custom-made technical ceramics. Featuring selection tables to speed determination of most useful composition for individual requirement, chart contains data on 17 frequently used compositions.

96. Radiographic Materials

Eastman Kodak Co.—16-page illustrated catalog "Materials & Accessories for Industrial Radiography" describes films for use with x-ray equipment of varying kilovoltage and with specimens of varying thickness and density. Information on relative speeds and contrast of different film emulsions is provided in handy chart.

97. Flexible Couplings

The Falk Corp.—8-page illustrated bulletin No. 8105 covers Airflex couplings, their construction features, method of selection for engine driven systems and for systems involving shock, and dimensions of various size units.

98. Sheet-Metal Fabrication

Karp Metal Products Co.—16-page illustrated circular "Custom-Built Sheet Metal Fabrication" depicts and describes facilities for all sheet metal manufacturing operations. Cabinets, mountings, apparatus components, access doors, control and distribution boxes, louvers and lighting fixture bodies are among products described.

99. Pressure Regulator Valves

Lear, Inc., Romec Div.—2-page illustrated product data sheet No. 6-10 gives data on series RB-7550 valves used to reduce pressures of as high as 100 psi to any constant lower pressure and to compensate for variations in inlet or atmospheric pressure, consumption rate, and pulsating inlet flow.

100. Wound Rotor Motors

Howell Electric Motors Co.—4-page illustrated bulletin SR-1 reviews line of wound-rotor motor delivering 1 to 150 hp at 1800 rpm and proportional horsepower at lower synchronous speeds. Slip ring motors are of induction type.

101. Coil Weight Calculator

F. J. Littell Machine Co.—Selection of correct size of Littell reel for specific group of coils is facilitated with this coil weight calculator which quickly determines exact weight of coil of steel. It also permits checking coil weights on bills of lading.

102. Welding Fasteners & Fittings

Ohio Nut and Bolt Co.—Nine 4-page illustrated bulletins enclosed in file jacket cover line of fasteners and fittings. Included are adjustable feet; adjusting screws; nuts, bolts, pads and bosses for projection welding; and Spotweld nuts and screws.

103. Conveyor Belting

Buffalo Weaving & Belting—4-page illustrated folder is entitled "What Conveyor Belts Are Available?" In it are described 35 widths of belt, 7 different plies and 6 different coatings that can be applied to adapt belts to various uses.

104. Swivel Pipe Couplings

Gil-Lair Products, Inc.—Illustrated catalog No. 50 describes design features, gives complete specifications and working pressures, and lists prices of All-Flex line of high and low pressure ball-bearing swivel pipe couplings. Also covered are steel rotary, steel cementing, marine and barge hose; mud mixing guns and steel circulating heads.

105. Tube Fittings

Parker Appliance Co.—8½ x 11-in. illustrated display card lists nomenclature for 14 tube fitting shapes and 5 fitting parts. All shapes are depicted, and chart relates tube size numbers with tube outside diameters and pipe thread sizes.

106. Plastic Injection Moldings

Loma Plastics, Inc.—4-page illustrated folder depicts facilities for plastic injection molding jobs. Moldings as large as 60 oz or 600-sq in. casting area can be accommodated, and products can be finished to specification.

107. Woven Wire Screen

Newark Wire Cloth Co.—64-page illustrated catalog D on woven wire screen and wire cloth products lists various types of screen and cloth for industrial applications. Engineering service, glossary of wire cloth terms, ordering information and various useful tables are included also.

108. High-Temperature Steels

United States Steel Corp.—87-page illustrated booklet "Steels for Elevated Temperature Service" discusses principles of elevated temperature behavior of ferrous metals, nature of "creep", measurement of flow under stress, and testing equipment used on high temperature steels.

109. Hydraulic Coupler

Snap-Tite, Inc.—1-page illustrated bulletin Vol. 1 No. 4, revised, and two attached data sheets explain ⅜ and ¾-in. improved hydraulic coupler with positive automatic shut-off for application to tractor-operated machinery. Coupler incorporates swivel action and U-packer to make it immune to flexing and vibration.

110. Ball Bearings

Marlin-Rockwell Corp.—7½ x 9-in. wall chart determines inch equivalents in decimals and fractions of M-R-C ball bearings in sizes from 1 to 300 mm.

111. Plastic Tubing

U. S. Stoneware Co.—24-page illustrated bulletin T-77 gives information on all formulations of Tygon plastic tubing, its uses, properties and chemical-resistant characteristics.

112. Industrial Engines

Packard Motor Car Co.—8-page illustrated booklet "Packard Industrial Power" deals with 327-cu in., 8-cylinder industrial engine available in choice of 16 models having ratings from 78 to 96 hp.

113. Blind Rivet

B. F. Goodrich Co.—6-page illustrated folder No. 6-7328-NS describes Rivnut blind rivet and nut plate made in one piece for joining sheet metal, tubular frame work, channel strips and air ducts.

114. Cold-Drawn Shapes

Rathbone Corp.—16-page illustrated booklet "The Rathbone Process" deals with production of special formations or shapes in metal bars by cold drawing. Shapes can be pinion or gear profiles, or contour of part can have any symmetrical or irregular shape.

115. Inorganic Colorants

Ferro Enamel Corp. — 28-page illustrated pocket-size booklet explains how inorganic colorants are manufactured for use in such organic vehicles as plastics, paints, printing inks, textiles, etc. Facilities for testing and matching as well as properties of various inorganic colors are listed also.

116. Antifriction Bearings

Anti-Friction Bearing Distributors' Association—20-page illustrated booklet titled "Installation, Maintenance, Removal of Anti-Friction Bearings" is comprehensive discussion of bearing care. Types of bearings, installation and removal are among subjects covered.

117. Vibration Isolators

Barry Corp.—8-page illustrated catalog No. 502 describes unit type air-damped Barry-mounts and mounting bases used to protect electronic equipment and other sensitive apparatus against shock and vibration encountered in aircraft applications.

118. Corrosion Data

Cooper Alloy Foundry Co.—4-page folder presents corrosion resistance of stainless, Monel and nickel castings in handy tabular form. Included are data relevant to organic and inorganic acids, salts, alkalies, oxidizing agents and other reagents.

119. Industrial Control Devices

Minneapolis-Honeywell Regulator Co. — 64-page illustrated catalog No. 8303 presents more than 100 different models of nonindicating electric, electronic and pneumatic controllers that have numerous industrial applications. Electronic, self-contained electric, and pneumatic insertion type temperature controllers; magnetic starters and contactors; heavy-duty pneumatic positioning motors, pneumatic automatic reset relays and electric step controllers are among recent additions to line that are described.

120. Automatic Safety Clutch

J. A. Strimple Co.—Illustrated leaflet "The Strimple Automatic Safety Clutch" deals with light and heavy duty clutches designed for any make of gasoline or electric motor. They provide efficiency and convenience wherever load starting requires high initial torque.

M. D. Numbers

1	21	41	61	81	101
2	22	42	62	82	102
3	23	43	63	83	103
4	24	44	64	84	104
5	25	45	65	85	105
6	26	46	66	86	106
7	27	47	67	87	107
8	28	48	68	88	108
9	29	49	69	89	109
10	30	50	70	90	110
11	31	51	71	91	111
12	32	52	72	92	112
13	33	53	73	93	113
14	34	54	74	94	114
15	35	55	75	95	115
16	36	56	76	96	116
17	37	57	77	97	117
18	38	58	78	98	118
19	39	59	79	99	119
20	40	60	80	100	120

MACHINE DESIGN 5-50
Penton Building
Cleveland 13, Ohio

Please send literature or detailed information on subjects circled at left to—

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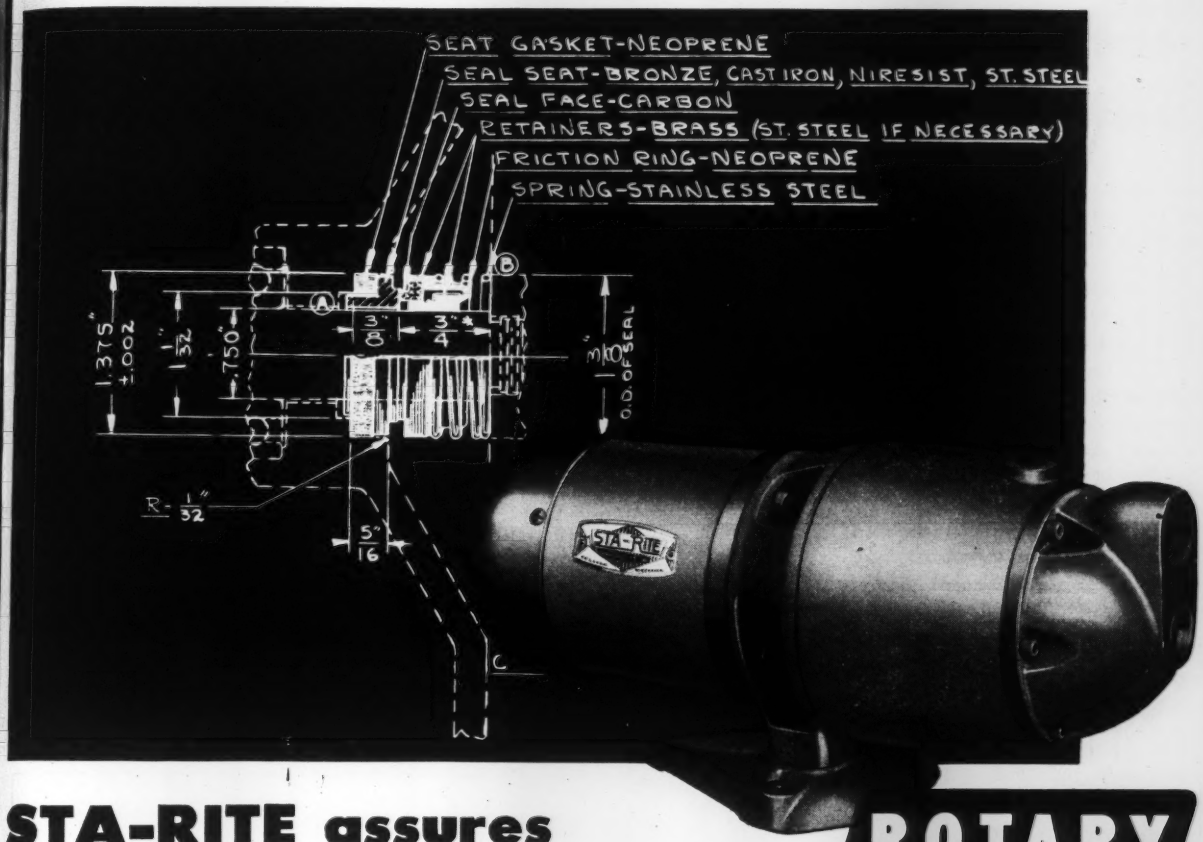


STA-RITE assures *Shaft-Sealing Certainty* with ROTARY SEALS

The Perma-Prime Jet Pump featured by STA-RITE Products, Inc., of Delavan, Wis., is built to give day-in, day-out operation during a long life on farms and in many other remote locations, far from service men. So every detail of this efficient, well designed unit must be just about trouble-proof. At the heart of the pump, Sta-Rite uses Rotary Seals to assure certainty in the Shaft Seal for the life of the unit.

Wherever use conditions for equipment demand *certainty* in Shaft Sealing, you'll find Rotary Seals will do the job. For STA-RITE, a special adaptation was made of the basic Rotary Seal principle which has solved tough sealing problems for manufacturers in many fields. Rotary Seal engineers can do the same for you—and, if called in at the drawing-board stage, can often suggest the simplest design approach from a Shaft Sealing standpoint, based on the wide variety of our successful experience. Write us today!

THE ROTARY SEAL PRINCIPLE

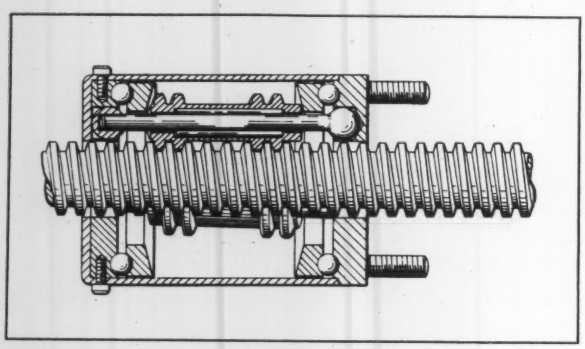
is the original approach to a practical solution of a universally troublesome problem. Our booklet "SEALING WITH CERTAINTY" explains and illustrates the principle. We're glad to send it to you without obligation.

THE mechanical seals for ROTARY SEAL COMPANY rotating shafts

2022 NORTH LARRABEE STREET
CHICAGO 14, ILLINOIS, U.S.A.

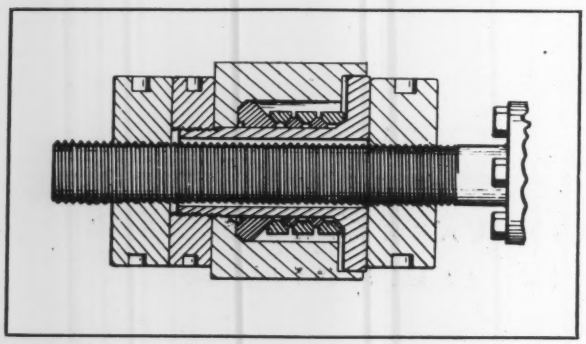
NOTEWORTHY PATENTS

REVERSIBLE JACKSCREW makes use of rolling contact instead of the usual sliding friction, i.e., a load on the screw will rotate the cage or nut structure. The unit is described in patent 2,488,256, granted to Emil Anderson and assigned to Electrolux Corp. Needle bearing mounted rollers are positioned in



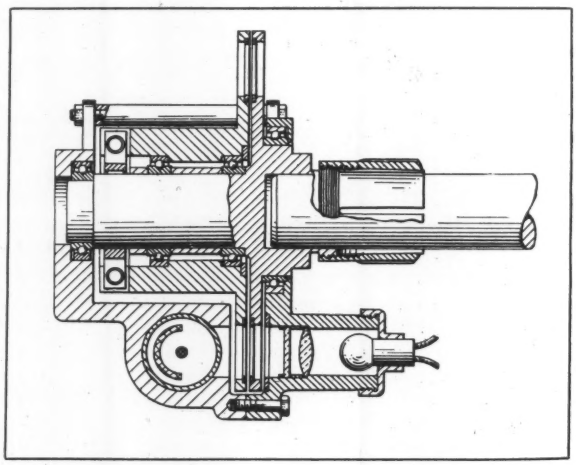
a cage with the roller axes at an angle to the screw axis. This angle is such that tooth-shaped grooves on the rollers are parallel to the lands of the Acme thread on the screw. Contact between screw and rollers is rolling, thrust from the latter being taken on ball bearing mounted thrust rings in the cage.

OVERLOAD PROTECTION for metal forming presses is provided by the simple device outlined in patent 2,485,009, assigned to E. W. Bliss Co. by Jules Muller. A set of steel rings around a sleeve secured to the driving element or plunger head of the press coact with slightly larger spring-steel spacer rings, mating surfaces between rings being of a taper or wedge shape. Press load is transmitted through the



two sets of rings and when pressure exceeds that for which the mechanism has been set, the outer rings expand radially, allowing the driving sleeve to move a distance sufficient to relieve the overload.

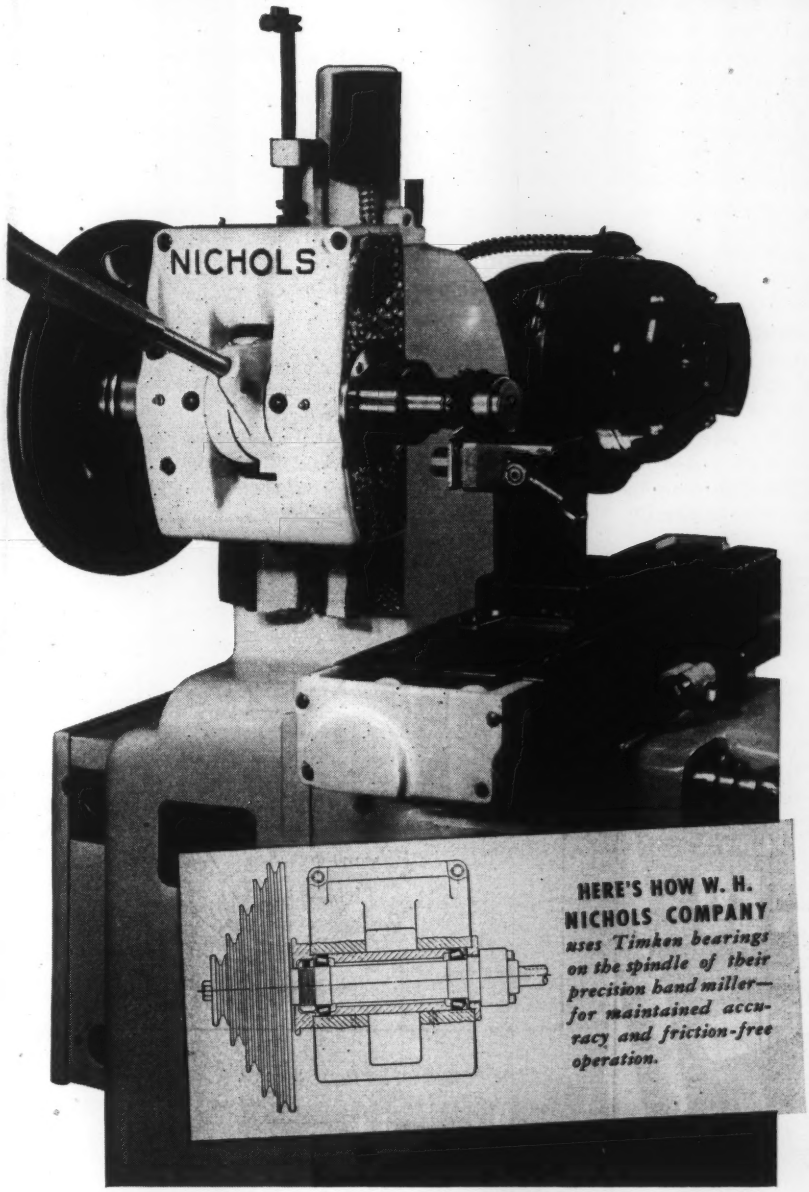
TORSIONAL VIBRATIONS in rotating shafts are measured photoelectrically, with vibrations capable of being read on an oscilloscope, as covered in patent 2,491,240 granted to Andrew W. Zmuda and Lawrence F. Hope and assigned to General Motors Corp. One of two slotted disks is attached to the shaft being tested, with the other disk driven from the shaft through flexible springs that permit floating in rela-



tion to the first disk. If the shaft is subject to torsional vibrations, the amount of light passed through the slots to a photocell will vary due to the change in the relative position of the two disks. Output from the photocell will give a periodic fluctuating reading the amplitude of which is a measure of the amount of torsional vibration present.

HIGH-SPEED PHOTOGRAPHY, with as many as 1300 successive exposures at rates to 800,000 exposures per second, for recording machine operation or other phenomena having a duration of a small fraction of a second, is possible with a camera developed by Kenneth Baird, assigned to The Honorary Ad-

Hand miller that "uses its head" has spindle mounted on TIMKEN® bearings



HERE'S HOW W. H. NICHOLS COMPANY *uses Timken bearings on the spindle of their precision hand miller—for maintained accuracy and friction-free operation.*

THIS Nichols hand miller "uses its head" to give unusual versatility as well as high standards of precision. The counter-balanced head slides up and down enabling the tool to be brought to the work for extra flexibility in many milling operations.

To insure smooth, accurate cutting and freedom from chatter, the spindle is mounted on Timken® tapered roller bearings.

Timken bearings help to hold the spindle rigid—keep it revolving accurately under all loads. The line contact between the rolls and races gives maximum spindle support. There's less chance of deflection. Tapered construction enables Timken bearings to carry both radial and thrust loads in any combination and permits accurate pre-loading. End-movement is controlled within the close limits required for precision machining.

Because of their true rolling motion and the finishing of rolls and races to incredible smoothness, Timken bearings practically eliminate friction. And since they're made of the finest steel ever developed for tapered roller bearings—Timken fine alloy steel—Timken bearings normally last the life of the machine.

For top performance, be sure you have Timken bearings in all the machine tools you build or buy. Look for the trade-mark "Timken" on the bearings. The Timken Roller Bearing Company, Canton 6, O. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

NEW TIMKEN BEARING CUTS RUN-OUT IN HALF!

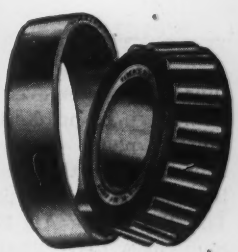
Until now, the Timken "Zero" bearing has been the last word in bearing accuracy. Now Timken offers industry the "Double-Zero" bearing—*twice as accurate* as the "Zero"! Maximum run-out of the new "Double-Zero" bearing is only 75 millionths of an inch—*half* the 150 millionths run-out of the "Zero" bearing.

What an opportunity for manufacturers of machines where extreme accuracy is essential! Available in standard single row types, up to 10" O.D. Write for further information.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

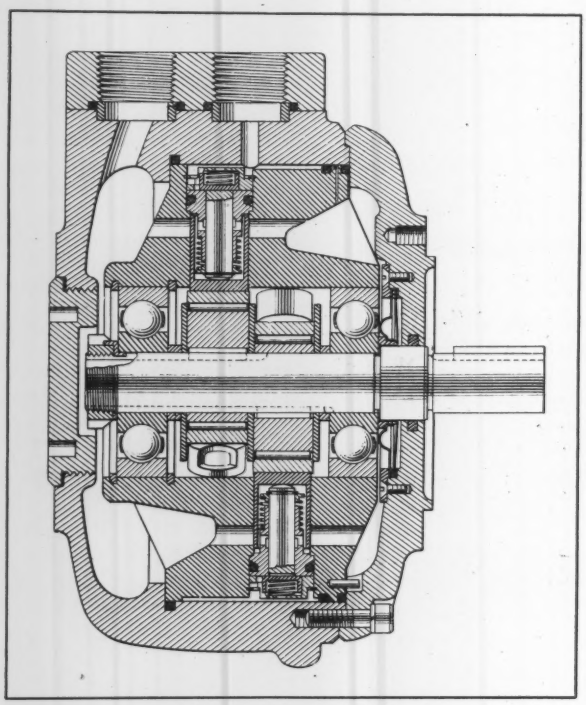
TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST →◫← LOADS OR ANY COMBINATION →◫←

visory Council for Scientific and Industrial Research, Ottawa, Canada. Patent 2,494,082 describes a camera in which the shutter consists of a motor-driven disk having evenly spaced slots around the periphery. These slots sweep past a series of 10 to 40 apertures, each of which has its own objective lens. Light passes through the slots and apertures, then through a common optical system, after which it is reflected by a prism onto the film wound around the circumference of a motor-driven drum. The prism is rotated at film speed so the reflected image travels in the same direction as the film to give sharper pictures. An additional shutter is used to limit the total exposure time to that required for one revolution of the film drum, or less.

VARIABLE VOLUME AND PRESSURE in a radial cylinder type pump without change of input power requirements is accomplished using interchangeable cylinder bushings and pistons. By using cup-shaped crosshead sleeves to absorb most of the side thrust from the eccentric piston-driving members, loose fitting cylinder bushings, to facilitate removal, can be tolerated. The entire shaft and cylinder assembly



thus can be removed from the housing by removing a snap ring and discharge valve holding each of the units in place. Cylinder and piston units of different capacity can then be substituted. The pump illustrated, covered by patent 2,472,355 and assigned to The New York Air Brake Co. by David J. Whittingham, uses two radial banks each having nine cylinders with the banks displaced 20 degrees from each other to obtain a smooth discharge flow.

PROFESSIONAL VIEWPOINTS

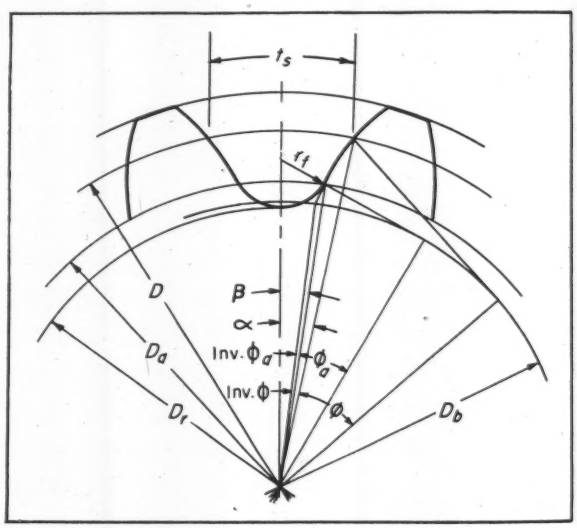
". . . a more direct solution"

To The Editor:

In regard to the article in the March 1950 issue of MACHINE DESIGN entitled "Calculating Fillet Radius of Gear Teeth" by Jerome Greene, we believe that there is a more direct solution to the problem than the one submitted by Mr. Greene. We are therefore submitting this solution for your consideration.

In the following equations,

r_f = Full fillet radius
D = Pitch diameter
D_a = Diameter at last point of involute
D_r = Diameter of root circle
D_b = Diameter of base circle
t_s = Arc tooth space at pitch diameter
ϕ = Pressure angle at pitch diameter
ϕ_a = Pressure angle at last point of involute



$$\alpha = \frac{t_s}{D}; \quad D_b = D \cos \phi$$

$$\cos \phi_a = \frac{D}{D_a} \cos \phi$$

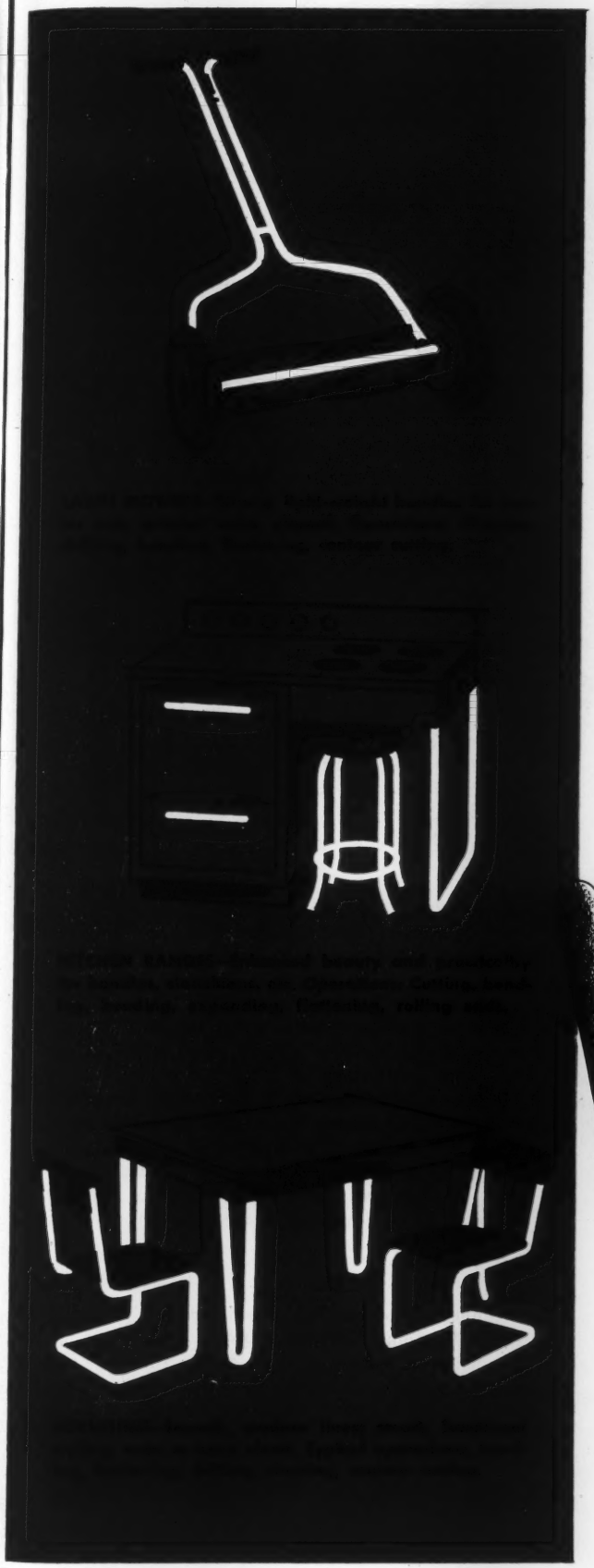
$$\beta = \alpha - \text{inv. } \phi + \text{inv. } \phi_a$$

$$r_f = \frac{D_b}{2} \left[\tan (\phi_a + \beta) - \tan \phi_a \right]$$

$$D_r = \frac{D_b}{\cos (\phi_a + \beta)} - 2r_f$$

Note that our solution does not require calculating the arc and chordal tooth space at the last point of the involute.

—OLIVER R. HALONEN and CECIL R. SESSIONS
Mathematics Department
Continental Aviation and Engineering Corp.
Detroit, Mich.



THE BIG TREND IS TO OSTUCO TUBING

Today, modern products of almost every description are being built entirely or in part from steel tubing. And with leading designers and manufacturers across the nation, the big trend is to OSTUCO Tubing. The reason—OSTUCO's "Single Source Service."

By performing all three basic tubing operations —manufacturing, shaping and fabricating—at one plant, OSTUCO speeds deliveries, assures uniform high quality, and appreciably reduces final costs.

Shipments from one supplier or one location to another are eliminated. Single control of production greatly reduces rejects and prevents errors in meeting your exact requirements. Responsibility is clearly fixed.

OSTUCO produces both seamless and electric welded steel tubing in a broad range of sizes and shapes . . . performs ALL types of forging and fabricating operations . . . supplies finished or semi-finished products. Write direct or to our nearest sales office for informative free booklet "Fabricating and Forging Steel Tubing."

From Your Blueprint . . . to Your Product

OSTUCO TUBING

Tapering • Swaging • Flanging • Bending
Upsetting • Expanding • Reducing • Beading
End closing • Spinning • Drilling • Slotting
Notching • Flattening • Shaping • Trimming
Threading • Angle Cutting • And Many Others

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Mac-it Stripper Bolts—heat-treated for strength, head concentric with body, ground to close tolerances.

BETTER, FASTER SERVICE WITH THIS *COMPLETE* MAC-IT LINE!

Because many standard types of Mac-its are stocked throughout the country for quick delivery, and because specials can be engineered to your own specifications, you'll find it pays to investigate Mac-its *first.*

Mac-it's 35 years' experience in the manufacture of heat-treated, alloy steel screws is your assurance of precision, uniformity and strength. Sold through leading industrial distributors from coast to coast and in Canada. Write for new catalog today!

Other Mac-it products include:

Hollow Lock Screws
Socket Head Cap Screws
Hollow Set Screws
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Socket Screw Keys
Square Head Set Screws
Hexagon Head Cap Screws
. . . and many others

Marketed Nationally Since 1913 by
STRONG, CARLISLE & HAMMOND COMPANY
Cleveland 13, Ohio
Manufactured by MAC-IT PARTS COMPANY, Lancaster, Pa.

NEWS OF MANUFACTURERS

The **Rice Pump & Machine Co.,** Milwaukee, Wis., formerly a division of **Milwaukee Chaplet & Mfg. Co.,** has been established as a separate corporation. The new corporation will continue the manufacture of the Milwaukee die filer, profile grinder and sprue cutters in addition to the Rice centrifugal pumps. The office and manufacturing operations will be continued at the present address.

♦

Complete modernization of the electrical system in the **Packard Motor Co.'s** mile-long plant will be finished shortly at an approximate cost of $100,000. A new phase of the company's safety program representing an expenditure of an additional $49,000 is being started with the installation of operating safety devices on 61 presses in the stamping division.

♦

The Cooper-Bessemer Corp., Mt. Vernon, O., has licensed **Harland and Wolff Ltd.,** British shipbuilder and engine manufacturer, to build Cooper-Bessemer V-type compressors. Covered by the contract are the type JM motor driven units and the GMX, GMV and GMW V-type gas engine-driven units.

♦

L. J. Wing Mfg. Co., manufacturer of heating, ventilating and combustion equipment and steam turbines, has consolidated three separate factories in Newark, N. J. and general offices in New York City into a single factory building at Linden, N. J. The new address is Vreeland Mills Road, Linden, N. J.

♦

The **Accurate Mfg. Co.,** Garfield, N. J., manufacturer of friction and rubber tapes, has completed its plant expansion program inaugurated early in 1949. The new building is a two-story structure which adjoins the present plant. The addition has trebled office space and provided area for processing and production expansion.

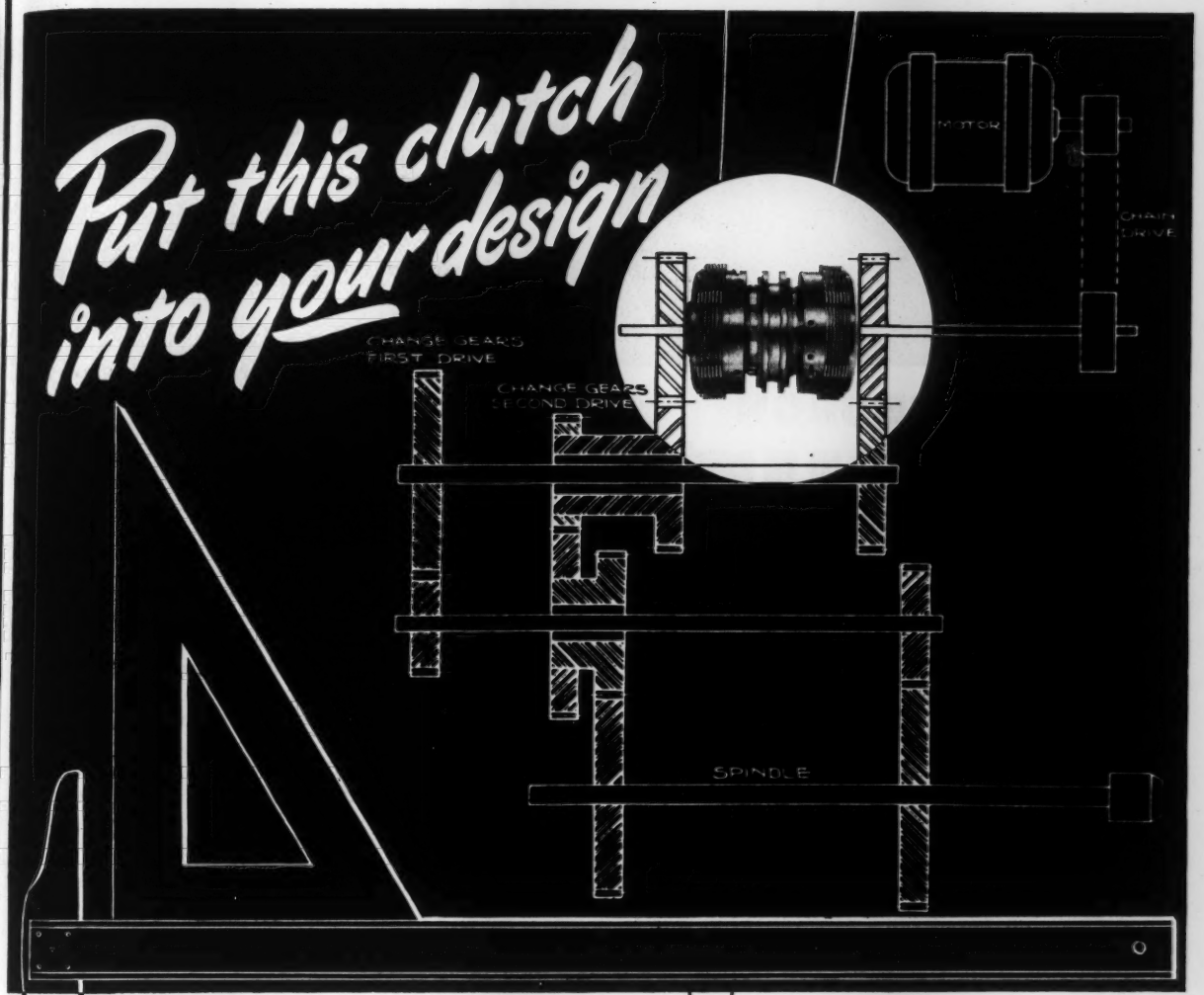
♦

Rehabilitation of the fire-destroyed plant of the **Nash-Christian Foundry Supply Co.,** Birmingham, Ala., manufacturer of high grade foundry facings, has been completed by **The Rust Engineering Co.,** Pittsburgh, Pa. The entire reconstruction was completed within sixteen weeks of the fire, permitting minimum delay in production schedules.

♦

Manufacturing and administrative activities of the **Marvel-Schebler Carburetor Division of Borg-Warner**

Put this clutch into your design



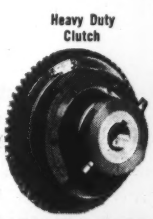
Twin Disc Machine Tool Clutches are engineered to fit easily into your design. They can be used as primary or cut-off clutches or as clutches that control a given function during continued operation . . . such as change-of-speed clutches where frequent operation is required.

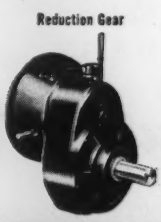
These compact Twin Disc Clutches have exceptionally high torque capacity compared with the relatively small space required for installation. For example, a 5.5″ Twin Disc Oil-type MTS Clutch with seven driving plates has a working torque capacity of 3200 inch-pounds.

This high torque capacity is obtained through use of materials with high friction coefficient . . . ample number of friction surfaces . . . a quick and easy method of removing oil from between the friction surfaces.

Twin Disc builds both oil and dry type Machine Tool Clutches . . . single and duplex construction . . . sizes from 3″ to 12″. For complete information write for Bulletin 134-A.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).





SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

PITTSBURGH

BRUSHES

OUTLAST COMPETITION 3 to 1

says the Bastian Blessing Company, Chicago manufacturer of soda fountains and equipment. Here power-driven brushes are used to satin finish brass parts and debur small threaded parts.

Frequent breakdowns and changes forced the company to seek a superior brush. From a wide variety of makes, Bastian Blessing selected Pittsburgh brushes because *"these lasted three times as long as the nearest competitive brush tested,"* . . . were softer, more flexible, and lasted longer . . . gave a better finish.

After three years of use, the company reports: *"Increased production, improved quality and greater material savings."*

Let "PITTSBURGH" skilled brush engineers show you what they can do

Just tell us your special brush problems and our staff of skilled engineers will quickly, efficiently design and build power-driven brushes to meet your requirements precisely.

Or you may find exactly what you are looking for in our regular Pittsburgh line . . . which includes sections, wheels and assemblies for every industrial use, whether it's glass, steel, or plastics . . paper, tires, shoes or automobiles.

For additional information, write or phone **PITTSBURGH PLATE GLASS COMPANY, *Brush Div.,* Dept. W-1, 3221 Frederick Ave., Baltimore 29, Maryland.**

PITTSBURGH *Power Driven* BRUSHES

BRUSHES • PAINT • GLASS • CHEMICALS • PLASTICS

PITTSBURGH PLATE GLASS COMPANY

Corp., now located in Flint, Mich., will be transferred to Decatur, Ill., during the late summer or early fall of this year. Physical limitations of the Flint plant, which made expansion impossible, dictated the necessity for the move. Negotiations are in progress for the sale of the Marvel-Schebler plant in Flint to E. I. duPont de Nemours and Co.

♦

Caterpillar Tractor Co., Peoria, Ill., has aquired approximately 300 acres of unimproved land near Joliet, Ill. on which it will build a new factory for the manufacture of a large portion of the company's line of bulldozers, scrapers, wagons and rippers. It is planned that final assembly operations from component parts produced by Caterpillar and subcontractors will start in the Joliet plant even before the building is completed and the necessary machinery for fabrication is installed.

♦

The **Hyster Co.,** Portland, Ore., has taken over the manufacture and sale of Turret Trucks formerly produced by the **Salsbury Corp.,** Los Angeles, Calif. The acquisition of the Salsbury horizontal materials handling trucks rounds out the previous Hyster industrial truck line consisting of four fork lift trucks, a mobile crane and two straddle trucks. Now manufactured at Hyster's Danville, Ill. plant, the new line will be known as Hyster Salsbury Turret Trucks.

♦

For the storage of its Youngstown Kitchens products, the **Mullins Mfg. Corp.,** Warren, O., is constructing a 147,000-sq ft, $700,000 warehouse at Warren. Mullins operates one plant at Warren where Youngstown Kitchens cabinet sinks and base cabinets are manufactured and two plants at Salem, O.—one devoted to kitchen wall cabinets and accessories, the other to porcelain enameled washing machine tubs, truck cabs and fenders, and other large metal stampings.

♦

By special agreement, the **Potter Instrument Co.,** Flushing, N. Y., has licensed **International Business Machines Corp.,** N. Y. to use the Potter basic electronic decade counter circuits developed by John T. Potter. These circuits form the chief element in the electronic counters and computers made for industry by the Potter firm. The agreement also cross-licenses the Potter company to use certain IBM patents.

♦

Gibson Electric Co., 8350 Frankstown Ave., Pittsburgh, Pa., has increased the production capacity of its powder metallurgy department fifty per cent by installing a sintering furnace, a brazing furnace, a hydraulic press for compressing powdered metals, an automatic weighing machine, and other processing equipment. Available floor space within the company's present plant was used for the new equipment.

Now available for oil hardening in entire range of thicknesses...

Brown & Sharpe Ground Flat Stock

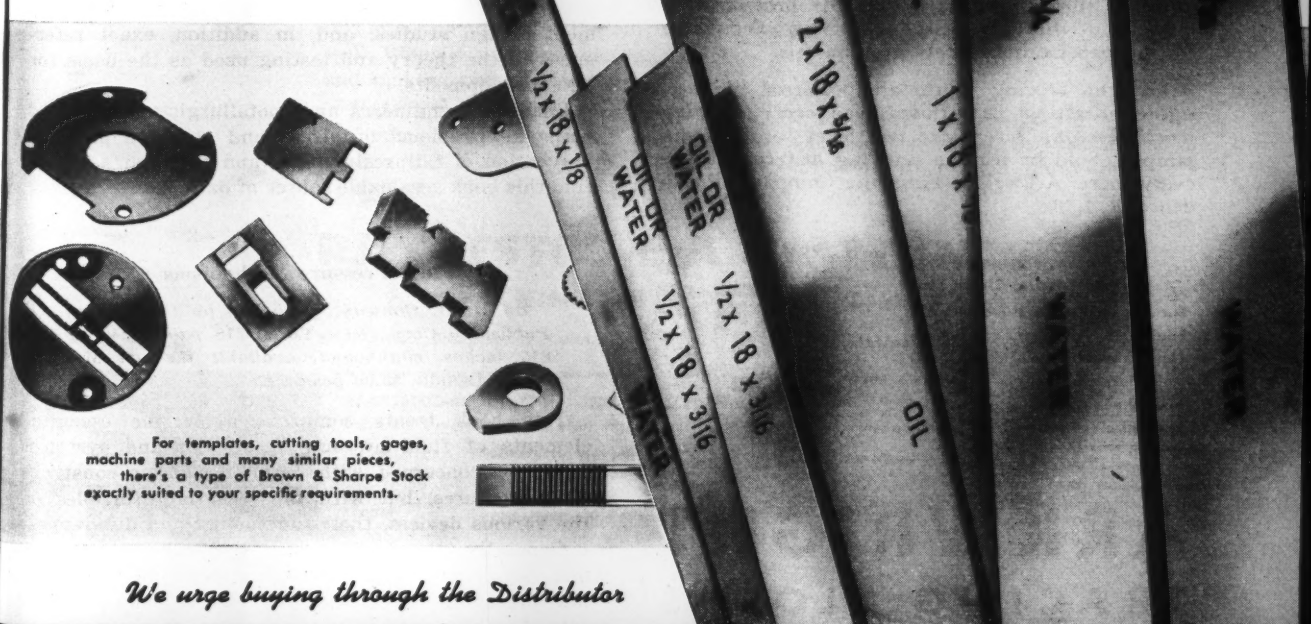
To help you get even greater benefits from the money-saving, time-saving advantages of using stock accurately pre-ground to size, Brown & Sharpe now offers a choice of oil or water hardening steel in 16 different thicknesses from 1/64" to 1".

In eight thicknesses up to and including 3/16", a single type of ground flat stock now serves for hardening in either oil or water . . . a distinct Brown & Sharpe feature that eliminates the expense of keeping two types of stock on hand.

With this complete range of stock — 145 sizes, including 24 new sizes — you can meet a wide variety of requirements. Stock for oil hardening is preferred where intricate sections and parts with sharp corners or abrupt changes in form are involved . . . for water hardening, where slightly higher hardness is needed.

Continuous, repeat markings of type on each piece of Brown & Sharpe Ground Flat Stock make identification easy. Protective envelopes in different colors simplify handling problems.

Write for new descriptive folder.
Brown & Sharpe Mfg. Co.,
Providence 1, R. I., U.S.A.

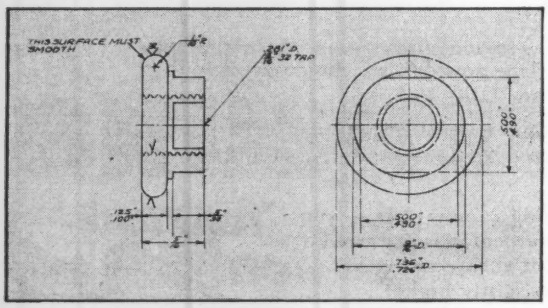

OIL
2 x 18 x 5/16
OIL
1 x 16 x
WATER
1 x 16 x 1/4
WATER
OIL OR WATER
1/2 x 18 x 3/16
OIL OR WATER
1/2 x 18 x 3/16
WATER
1/2 x 18 x 1/8
For templates, cutting tools, gages, machine parts and many similar pieces, there's a type of Brown & Sharpe Stock exactly suited to your specific requirements.

We urge buying through the Distributor

BROWN & SHARPE B·S

with STEEL CABLE

— the small extra first cost of test samples pays off in assurance of efficiency and durability of the finished structure.



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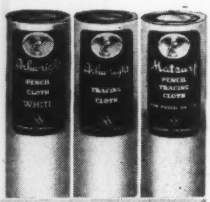

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Stress and Strength of Manufactured Parts

By Charles Lipson, consulting engineer, G. C. Noll, project engineer, The Thew Shovel Co., and L. S. Clock, assistant professor applied mechanics, University of Detroit; published by the McGraw-Hill Book Co., New York; 259 *pages,* 6 *by* 9 *inches, clothbound; available through* MACHINE DESIGN, $4.50 *postpaid.*

This book, in two parts, presents data which assists in the establishment and use of "design factors" substantially lower than the well known "factors of safety" because they take into consideration the influence of material and processing tolerances. Part I treats in concise manner the basic facts governing stress and strength with emphasis laid to the proper balance between the two. Significant strength is discussed with respect to mode of loading, surface finish, hardness, surface treatment, and life expectancy; significant stress from the standpoint of mode and type of load application and stress concentration. Part II consists of 175 charts pertaining to geometric stress concentration factors, fatigue stress concentration factors for annealed and quenched and drawn steels, and allowable working stresses for infinite and finite life of parts taking into consideration types of finish such as ground, machined, hot rolled and as forged. Although the specific data presented pertains only to steel members, the general principles employed are applicable to other materials. The appendix includes an extended bibliography to supplement design studies, and, in addition, exact references to the theory and testing used as the basis for text developments.

Designers, engineers and metallurgists confronted with the problems of stress and strength and the prevention of failures of parts and assemblies should find this book a valuable source of data.

□ □ □

Fluid Pressure Mechanisms

By H. G. Conway; published by the Pitman Publishing Corp., New York; 218 *pages,* 5½ *by* 8½ *inches, clothbound; available through* MACHINE DESIGN, $5.00 *postpaid.*

This book treats comprehensively the essential elements of fluid pressure equipment and systems. It is not concerned with detail design or constructional features, but with the essential principles of the various devices, their functioning and differences.

Generally, the book covers hydraulic, pneumatic and compressed gas systems of high, medium and low pressures. Specifically, it can be broken down into two divisions. Part I covers mechanisms in logical order: Sources of power—pumps; receiving units — motors, jacks, cylinders, etc.; controlling

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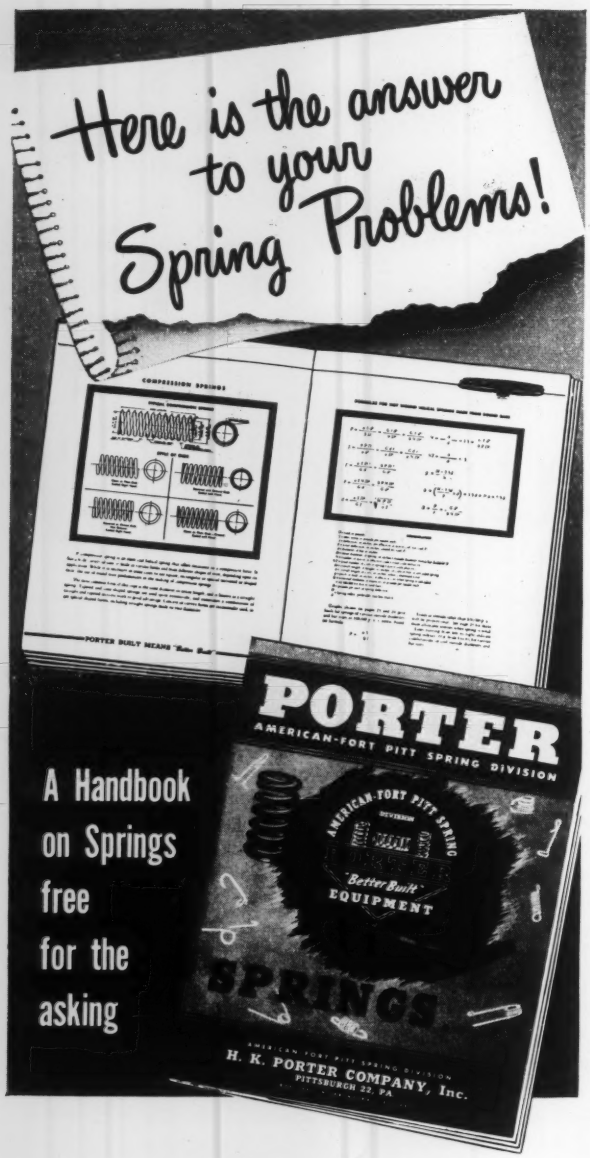
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elements — valves; piping — fittings, couplings, etc. Part II is concerned with pressure systems: Elementary power, remote control, variable speed, sequence, servo, electric control, and others.

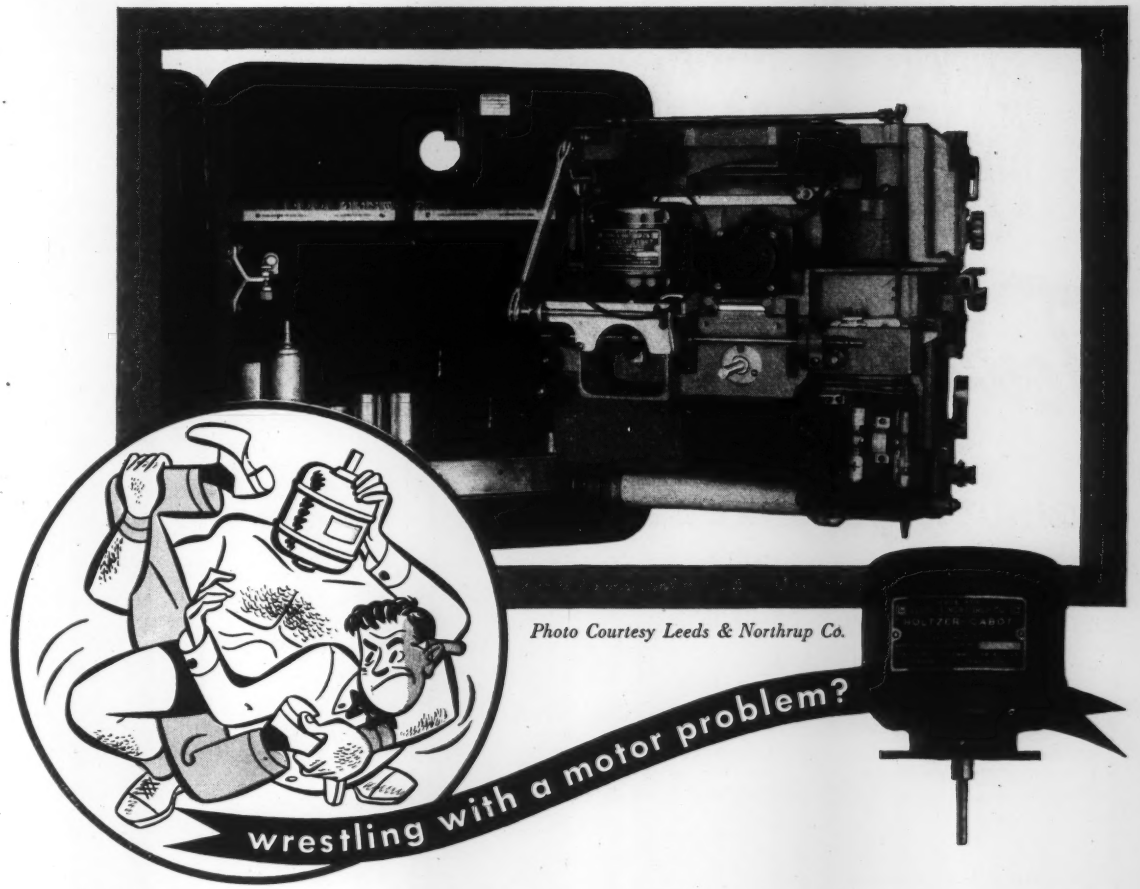
All sections are well supported by diagrams and so presented as to afford thorough comprehension of the essentials of fluid pressure equipment and systems thereby assisting materially the design of such components and systems.

Manufacturer & Association Publications

Welding Handbook — Third Edition: This 1651-page, 6 by 9-inch manual of welding practice treats the subject according to the following principal divisions: Welding fundamentals, welding processes, cutting processes, metals, design and cost considerations, inspection and quality control, applications, AWS standards, and general engineering data. More than 300 tables support the divisions and illustrations are generously used to show welding equipment, welding details and specific applications. Material which appeared in the 1942 edition has been revised so that all data is up to date. The manual should serve as a reliable source of information for engineers engaged in the design of weldments. Copies may be obtained from the American Welding Society, 33 West 39th St., New York 18, N. Y. The price per copy is $12.00 in the United States and Canada, $13.00 elsewhere.

Dictionary of Electronic Terms: This 6 by 9-in., 64-page book contains concise definitions of some 2500 terms used in radio, television and electronics. Covering mostly modern techniques and equipment, the definitions range from words not too generally used but retained for historic reasons to those used in the fields of color television. More than 125 illustrations and diagrams of components, equipment and circuits are included as well as an appendix of radio data. Copies are available from the Allied Radio Corp., 833 West Jackson Blvd., Chicago 7, Ill. for $0.25 each.

Techniques of Plant Maintenance: This two-volume text covers the proceedings of the Conference on Plant Maintenance sponsored by the American Society of Mechanical Engineers and the Society for the Advancement of Management held concurrently with the Plant Maintenance Show in Cleveland, O. The first volume discusses informatively maintenance organization and principles; maintenance cost and budgeting; selection and upkeep of lighting equipment; use of electrical instruments in maintenance; upkeep of floors, walls and roofs; relationship of lighting and color to production; sanitation and housekeeping; lubrication; application of service equipment; and the protection of plant and worker. Each of the divisions has been prepared by men well acquainted with the problems involved. Five hundred and fifty-four questions submitted by the audience are answered in the second volume. Comprising 278 pages, 8½ by 11



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If you are, we'd like to help you. Quite often instrument manufacturers encounter motor application difficulties that are troublesome and not easy to overcome. Then the call goes out for Holtzer-Cabot. Over a period of seventy-five years, Holtzer-Cabot has tackled a wide variety of tough motor application problems and has always been able to provide the correct solution.

Here's a typical success story from our files . . .

Leeds & Northrup Company, a leading instrument maker for 51 years, in the early 1920's used a governed series motor to operate their automatic recording instruments. They desired greater accuracy in instrument chart speed and were also anxious to eliminate the governor. Holtzer-Cabot recommended a specially designed horizontal synchronous motor for this service. From the early '20's until 1933 this installation worked well and gave satisfaction.

Then to improve their product further, Leeds & Northrup desired a vertical synchronous motor in order to save space, and to eliminate a centrifugal cut-out. Leeds & Northrup approached us with the problem, and after burning the midnight oil, our Research Department came up with the answer . . . the Holtzer-Cabot RBC-3712. This trouble-free motor has been eminently satisfactory and we have been privileged to supply Leeds & Northrup with a large percentage of their requirements, so that today many thousands are giving dependable service the world over.

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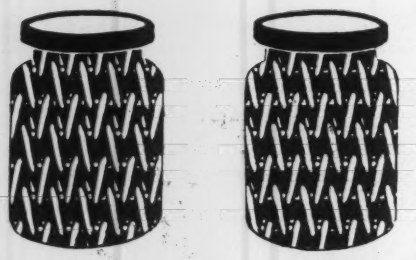

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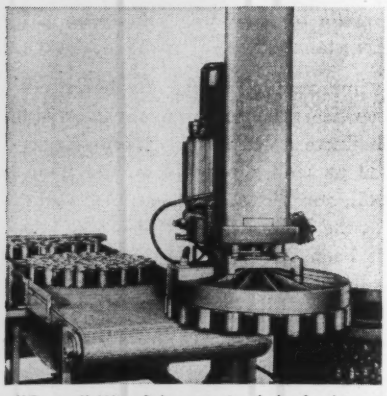

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inches, with 47 pages of tables, diagrams, graphs, and charts, this text provides an excellent source of data pertinent to the vital problem of maintenance. Copies are available from Clapp & Poliak Inc., 431 Madison Ave., New York 17, N. Y. Price for both volumes, postpaid, is $2.00.

ECRC Proceedings—1949: The Engineering College Research Council of the American Society for Engineering Education highlights this publication of its 1949 annual meeting proceedings with a symposium of twelve papers on instrumentation for engineering research. Covered by the papers are: Conju-gage for gear inspection, polar vector indicator for alternating voltage study, new light source technique for photo-elastic stress analysis, null-balance optical bridge, SUI polyphase oscilloscope, slope measuring device, a-c visualizer, network analyzer, thermopile heat and wave meters, and magnetic amplifiers. Other papers in the publication describe military and non-military engineering research interests as reported to the Research Council by the Armed Forces, Public Health Service, Highway Research Board, NACA, and the Department of Agriculture. Copies of the 140-page, paper-bound book may be ordered from the Office of the Chairman, Engineering College Research Council, State University of Iowa, Iowa City, Iowa, at $2.00 each, postpaid.

Metal Cutting Tool Handbook: An excellent source of data for engineers and designers engaged in the metal cutting and metal cutting tool fields. The book is divided into sections on twist drills, reamers, counterbores, taps, dies, milling cutters, hobs, gear shaper cutters, and broaches. Each section contains pertinent data on standards, maintenance, speeds, feeds, operating conditions, etc. Tables of commercial sizes of each type of tool are included. Considerable space at the end of the book is devoted to engineering data—design standards, formulas, metallurgy, etc. commonly used in the field. Copies of the 647-page book may be obtained from the Metal Cutting Tool Institute, 405 Lexington Ave., New York 17, N. Y. Price per copy, $6.50.

Modern Methods of Gear Manufacture: An 8¼ by 10¾-in., 172-page third edition which should serve as a permanent, reliable source of gear design data. Treated in this compilation are: Design principles, formulas, steels and forgings, heat treatment, machining, advanced production practices, special problems with case histories, and broaching. Each phase is concisely informative and well supported by tabular, graphical and illustrative material. For example, the chapter on design principles includes discussions of surface deterioration, normal wear, run-in wear, contact welding, grinding, pitting fatigue, fine pitches, pressure and helix angles, elliptoid tooth forms, elliptoid shaving, automotive transmissions, timing gears, splines, and camshaft gear shaving. Copies may be obtained from the National Broach & Machine Co., Detroit, Mich. Price, $10.00 per copy.

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5 to 8 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.

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Note: 10 and 15 ampere contactors have same mounting and overall dimensions.

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To replace contacts, it is not necessary to disassemble the complete contactor. Just remove the parts comprising the stationary and movable contacts. Contacts can be replaced without disturbing wiring. To change coil, remove magnet frame and coil assembly only. (See illustration below.)

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Using a screw driver only, you can easily change any pole from normally open to normally closed. No special parts required. 10 and 15 ampere parts are interchangeable.

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Laboratory tests involving millions of operations, plus field service of thousands of R-B-M contactors on door operators, radio transmitters, packaging and weighing machinery, hoists, machine tools and many other industrial applications offer proof of dependable, trouble-free performance.

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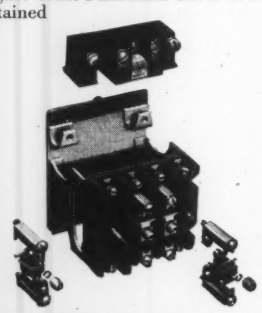

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RBM

MANUAL AND MAGNETIC ELECTRIC CONTROLS
— FOR AUTOMOTIVE INDUSTRIAL COMMUNICATION AND ELECTRONIC USE

Computer Components

(*Continued from Page* 134)

With the induction potentiometer the life is many times greater because both materials of the contact pair can be selected as contact materials only and, in any case, wear does not affect the voltage output.

Is Isolated Between Excitation and Output

A second advantage of the device is that it in itself provides isolation between its excitation voltage and its output. With the resistance potentiometer, the outputs of two units can be added in series only by providing a separate excitation transformer for each of them. These transformers would require standardization by means of auxiliary resistors and capacitors to insure that their voltages and phase angles were alike when loaded with their respective loads. Such standardization is built into the induction potentiometer when it is made.

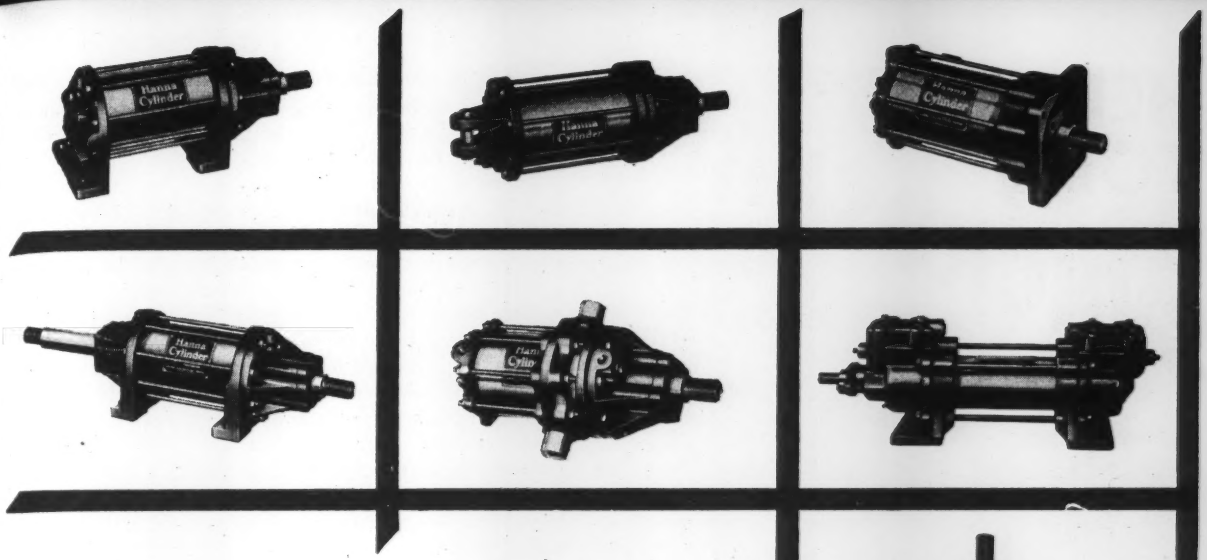
If this difficulty is avoided by using the parallel or resistor to a common point method, the resistors must be very large or the potentiometers made of very low resistance. The output impedance of a potentiometer varies from 0 to ¼ of its actual resistance and back to 0 as the slider moves from end to end. Thus, if the potentiometer has a resistance of 1000 ohms, the load resistor should exceed a half megohm in order to avoid an error of more than 1/2000 of the reading at the midpoint. This error can be compensated by using a nonlinear potentiometer, or an auxiliary rheostat, or it can be reduced by means of suitable resistance networks.

If Load Is Light

The use of low-resistance potentiometers to keep the load down introduces several other difficulties. The magnitude of the individual steps becomes bothersome, particularly if the potentiometer is used as the response member in a servomechanism, and the power consumption goes up, with an increase in the operating temperature of the unit. If this temperature increase is uniform over the potentiometer and any trimming resistors, an error should not be introduced, but it is necessary to consider these factors.

In computers which are not intended to position appreciable load, the induction potentiometer has the further advantage of requiring much less power to drive it than the resistance device. An induction potentiometer requires about 3 milliwatts to drive it from zero to full output in one second, while the usual 10-turn precision potentiometer will require about 1 watt. Many satisfactory computing servos have power outputs of the order of 0.1-watt under normal conditions. Therefore, if rapid computation is needed, large motors and amplifiers would be required to drive resistance units.

It is not intended to maintain that resistance units



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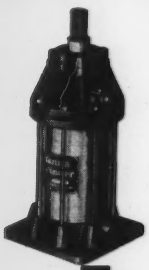

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THE NEW, POSITIVE, FLUTTERLESS STARTING SWITCH . . . . .

FOR EVERY SPLIT PHASE and CAPACITOR TYPE, SINGLE PHASE FHP MOTOR

NOTE THESE ADVANTAGES:

1. Simple—only one moving part.
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5. Bakelite shaft collar is supported by the switch, free and clear of shaft; no interference by accummulated dust or dirt.
6. Action is positive and uniform, regardless of load condition and acceleration rate of motor.
7. Assures many times the normal life of contacts, starting windings and capacitors.

HOW *SYNCROSNAP** WORKS

The TORQ SYNCROSNAP starting switch or centrifugal governor is the most revolutionary development in the FHP single phase field. As illustrated, the only moving part of the switch is the SYNCROSNAP* disc, with integral fingers, stamped as a single piece from special spring metal. Factory pre-set to act at any specified speed, with an accuracy of + — 2%, SYNCROSNAP* maintains that accuracy of response throughout the life of the motor. Action is lightning fast. The disc must be in or out. There is no halfway point so all "flutter" and "chatter" are wholly eliminated.

SYNCROSNAP* is now available in production quantities for motors from ⅛ to ½ HP; shaft diameters ⅜ to 13/16 inches; speeds from 900 to 3600 RPM. Other models are being developed, suitable for varying shaft diameters, larger and smaller motors and for varying dimensional limitations of rotor diameters and overall shaft lengths.

Get full information about TORQ SYNCROSNAP winding protection for your own motors. Phone, wire or write today.

* Patent Pending

TORQ ELECTRIC CORPORATION

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may not be useful in many applications. Where computation can be slow or, if it is fast, where the accuracy need not be high, the resistance potentiometer is probably the best unit to use.

There is an occasional case in which higher accuracy is required than can be obtained from either an induction or a resistance potentiometer. In this event, such a potentiometer can be used as an interpolating device to be employed in conjunction with a step potentiometer of higher precision. This principle is that employed in ordinary potentiometers of the type used for precision measurements. The accuracy of the steps is limited only by the drift of precision resistors with time and, if necessary, can be made of the order of 0.001 per cent. Taps on a proper transformer winding can have about the same accuracy, and are free from drift with time. They have the further advantage of providing a low output impedance with a higher input impedance.

Another method of addition and subtraction is by means of the synchro differential. Synchro units are made under various proprietary names by many manufacturers and need not be described in detail.

Transmitter Has Three-Phase Winding

A group of Synchros is shown in *Fig.* 6. The usual synchro transmitter has a salient pole rotor with pole pieces so shaped as to give an approximately sinusoidal flux distribution, and a distributed three-phase secondary winding. The output of each phase of the secondary winding varies sinusoidally with the angular position of the rotor. The three space phases reach their respective maxima in the same direction at 120 degree shaft intervals. The time phase of the carrier or excitation frequency is, of course, constant.

The output winding of the transmitter is connected to the input of a synchro control transformer or receiving unit which has a three-phase primary winding and a single-phase secondary. The secondary is ordinarily a distributed winding on a core having the same reluctance for all positions in the field. As the rotor is turned the output voltage will vary sinusoidally and, at two points 180 degrees apart, will pass through zero except for a small quadrature residual. If now the transmitter is rotated through any angle, the control transformer must be rotated through the same angle to locate the new zero points. The voltage from the output of the control transformer is usually employed to control a servo to bring the output to zero.

Is Connected Between Transmitter and Transformer

The synchro differential has three-phase windings on both rotor and stator. It is connected between the synchro transmitter and the control transformer with its primary winding to the transmitter and its secondary to the receiver. With this arrangement the rotation of the control transformer will be the sum or difference of the rotations of the transmitter and the differential generator, depending on the particular way in which the units are connected

Another cost-saving advantage for users of

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TAILOR-MADE SURFACE

FINISHES

to match production, fabrication, or end-use requirements

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B&W MECHANICAL TUBING

TYPES—Seamless (hot finished and cold drawn). Welded (from hot or cold rolled strip).

GRADES—Carbon, Alloy, and Stainless.

SIZES—Up to 8¾" O.D. in full range of wall thicknesses.

QUALITY—Open-hearth and electric furnace steels, including aircraft and magnaflux qualities.

CONDITION—Unannealed, annealed, tempered, normalized, or otherwise heat-treated as required.

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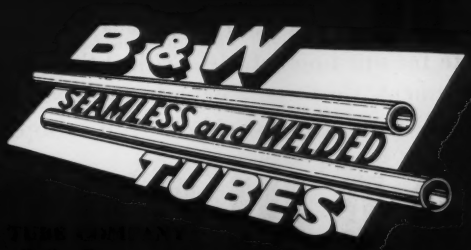

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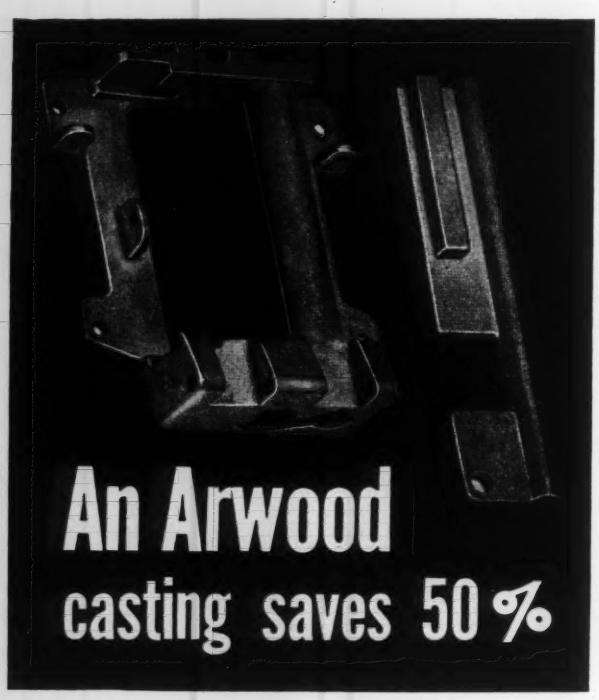

Here is a typical example of what ARWOOD precision castings can do. Such results are made possible only by ARWOOD'S years of experience that spells "know-how."

Five parts — 2 stamped and 3 machined — formerly had to be brazed together to make the bronze key guide housing shown at left above. The Lathem Time Recorder Co. reports their costs were reduced 50% when a single ARWOOD Precision Casting replaced the five-part assembly.

The key shown at right is also an ARWOOD Precision Casting which fits the keyway without any adjustment.

ARWOOD Precision Investment Casting is now a tested and important method for producing small intricate parts. It has been the answer to many design and production problems and can be the answer to yours. Write for our booklet, "A Critical Survey of Investment Castings," or ask to have our nearest representative show you samples.

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together. *Fig.* 7 shows how this is done.

The accuracy of many synchro units is surprisingly high and is much higher than has been required by Navy specifications in accordance with which they were made. One reason for this is that at the time the specifications were written no satisfactory absolute measure of their accuracy had been devised. There is naturally considerable difference between the products of various manufacturers but maximum errors of two or three tenths of a degree are normal.

Accuracy of a synchro transmission system can be increased many times by the expedient of employing double or triple systems. That is, a system operating at a relative speed of one is used to position the driven member approximately. Control is then shifted to another system operating at a higher relative speed, perhaps 125. Thus, the final error will be reduced to 1/125 of that of the simple synchro system. Addition of two quantities is then made by means of synchro differentials in each line geared together in the proper ratio. Amplifiers are available which incorporate means for transferring control from the low-speed or coarse system to the high-speed or fine control system at the proper time. Some of them also incorporate servo damping devices. Double-speed addition is shown in *Fig.* 8.

Subsequent articles in this series will discuss the more complex algebraic operations and applications of computers for solving common problems.

Machine Hydraulics

(*Concluded from Page* 125)

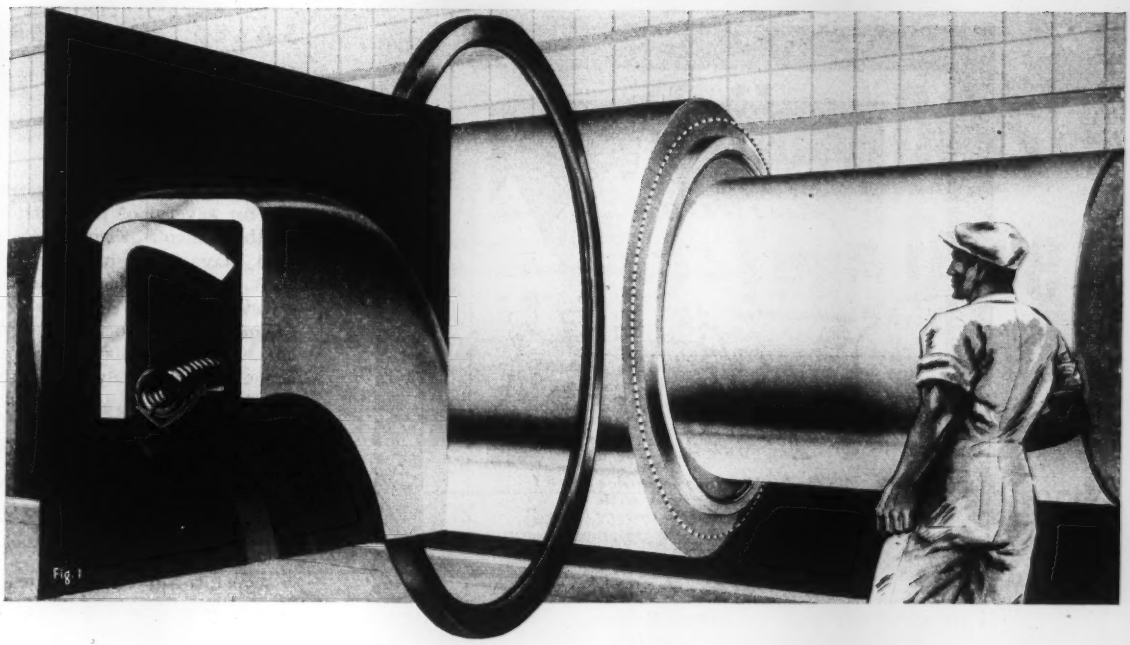
must have been the forerunner of the modern transfer or run-around valve, enabling some of the fluid escaping from one end of a cylinder to transfer directly to the other end while the pressure there was low.

Many of these early hydraulic installations made use of selector valves, relief or safety valves, etc., very similar to those in use today. The origin of the reducing valve is not clear but Adams refers to "the application of accumulator pressure to fire-extinguishing purposes" in 1854, at the West India Docks (London) by means of a reducing valve. Relief and reducing valves probably were developed from the steam practice of the day. The adjustable steam relief valve is credited to Denis Papin (1681).

In *Fig.* 15, reproduced from the Proceedings of the Institution of Mechanical Engineers for 1857, is shown a railway steam feed pipe connection using rubber O-ring seals and described as being installed with radial interference. These seem singularly like the modern O-seal invented by Christiansen.

While sealing technique, without modern honing and polishing equipment, could not have been so good as today, results must have been satisfactory. Certainly engineers were not afraid to use hydraulic power on a large scale 100 years ago. In 1849 Robert Stevenson and William Fairbairn, by hydraulic jacks, lifted to a total height of 100 feet the tubular girders, each weighing 1800 tons, of the Britannia bridge in successive operations. The seals must have been pretty good.

NATIONAL OIL SEAL LOGBOOK



where the going is BIG, rugged and hot... National Oil Seals meet a severe test

The high peripheral speeds and extreme ambient conditions encountered in main bearings of large rolling mills pose tough problems in bearing protection. The problem is aggravated by the presence of copious quantities of scale and the use of special coolants. Thus the actual sealing members of oil seals must in many cases be fabricated of materials which are impervious to breakdown when exposed to water and other coolants.

The National Oil Seal shown (Fig. 1) is successfully employed on the roll shafts of a large sheet steel mill machine. In this case the sealing member is made of National "Syntech"* synthetic rubber compound. The construction of the seal is identical to the basic National 50,000-S type used in hundreds of other applications. The seal itself is unusual in size since shafts on this equipment run between three to five feet in diameter while a section through the seal is under one inch. Close tolerance must be observed inasmuch as these seals must "press-fit" into the housing bore in the accepted manner and rugged construction is necessary to withstand rough handling when it becomes necessary to repair the equipment, which must of necessity be done hurriedly. Two such seals are utilized in each position: one to seal the lubricant in and the other to withhold contaminating extraneous matter which includes scale and coolant. This is done to effect economy in replacement.

These National Oil Seals provide efficient bearing protection despite the extraordinarily rugged surrounding conditions and the extreme peripheral speeds. Experience has shown that performance of this kind can be achieved without resort to special designs. This particular seal (Series 50,000-S type) is available in a wide range of sizes from dies already on hand. National Oil Seals engineers will be happy to consult with you on any bearing protection problem. Please write for additional information.

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DETROIT, MICH.	Room 1026 Fisher Building, Trinity 1-6363
HOUSTON, TEXAS	6731 Harrisburg Boulevard, Wayside 3-1246
LOS ANGELES, CALIF.	2244 East 37th Street, Kimball 6384
MILWAUKEE, WIS.	647 West Virginia St., Marquette 8-8986
NEW YORK CITY, N. Y.	122 East 42nd Street, Lexington 2-8260
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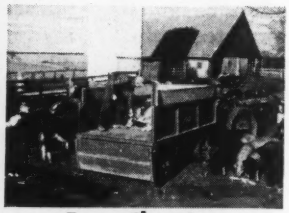
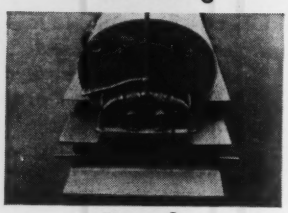
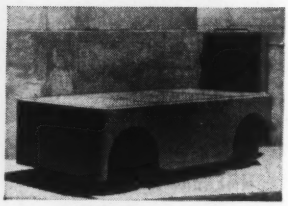


Easy Cleaning



Firesafe



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SALES AND SERVICE PERSONNEL

THE WELDING engineering staffs for several of the district offices of the Lincoln Electric Co., Cleveland, have been increased recently. **J. W. Brooks** has been made welding engineer in the Boston area; **J. J. Chemerys,** who formerly worked for the Joy Mfg. Co., is serving industrial accounts in the Syracuse territory; **W. R. Karll** has assumed sales and engineering responsibilities in Lincoln's Newark, N. J. office; and **R. G. Todd** has been added to the welding engineering staff of the company's Tulsa, Okla. office.

♦

Appointment of **Phil Norton,** general sales manager of Wisconsin Motor Corp., Milwaukee, as a vice president of the company, was announced recently. He has been connected with the company in a sales capacity for more than twenty years, occupying the executive position of general sales manager for the past ten years.

♦

American Screw Co., Providence, R. I., has named **John J. Coy** assistant sales manager. He has been a sales representative for the company for the past twelve years, with headquarters in Dayton, O.

♦

According to a recent announcement from Chicago Vitreous Enamel Product Co., **John L. McLaughlin** has been appointed assistant manager of service. Having first joined Chicago Vit in June of 1937, he has held various research and service positions with the company and is well qualified for his new post.

♦

John B. Moxness has been appointed industry engineer in charge of sales promotion of control devices for Brown Instruments division of Minneapolis-Honeywell Regulator Co.

♦

Having served for many years as active head as well as sales director of the U. S. Steel Wire Spring Co., 7800 Finney Ave., Cleveland, O., **O. C. Berkobein,** president, is now relinquishing his sales duties and will devote his time to overall policy planning and direction of the company's entire operation. Also, in line with the company's expanded production facilities and its desire to better serve

These Features Save You Money	For These Reasons	It's a Worthington—
1 Two-piece QD sheave—rim and hub separate	Mount light hub first, then slide heavier rim on tapered hub	EXCLUSIVE
2 Choice of one or two-piece assembly	Mount hub and rim separately, or loosely assemble hub on rim and slide on shaft together	EXCLUSIVE
3 Split hub	Easy to mount, even on oversized shaft	ORIGINAL
4 Clamp screw in hub	Holds hub in position on shaft while setting or removing rim	EXCLUSIVE
5 Taper-mated hub and rim	Mount easily in any position—no keyway between taper surfaces	ORIGINAL
6 Large, long pull-up bolts	Hold better and more uniformly	EXCLUSIVE
7 Friction cone grip	Tightening rim on hub gives positive press fit on shaft	ORIGINAL
8 Shaft key lock (set screw over keyway)	Prevents key from drifting	EXCLUSIVE
9 Quickly-detachable (QD)	Pull-up bolts used as jack screws to remove sheave rim	ORIGINAL
10 Interchangeable rims	Hubs for every bore—lower inventory cost	ORIGINAL
11 No realignment problem	Clamped hub holds shaft position—new rim tightens up in exact alignment	EXCLUSIVE
12 Choice of "A", "B", "C" and "D" grooves	"Tailor-made" grooves give proper belt "ride-out" for maximum life efficiency	ORIGINAL
13 I-beam spokes on driven sheave	Stronger—capable of carrying heavier load with less weight	EXCLUSIVE
14 Offset design of sheave	Reduces over-hang loads—increases bearing life	ORIGINAL
15 Worthington-Goodyear V-belts	Load-carrying cords in neutral axis reduce internal friction—each belt carries its share of drive load	ORIGINAL

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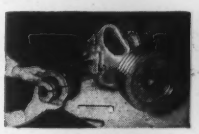

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customers, is the appointment of **Walter J. Kimpel** as sales manager. He has been associated with the spring industry for over thirty-five years and until recently was sales manager of Cleveland Wire Spring Co.

♦

Chester W. Schweers, manager of Allis-Chalmers' Los Angeles district since January, 1947, has been named manager of the company's New England region with headquarters in Boston. Mr. Schweers entered the employ of the company in 1930 and served as a sales engineer in the New Orleans office for nearly ten years before becoming manager of the Houston office in 1942.

♦

With a territory including all of Alabama, South Carolina, Georgia and Florida, and parts of Tennessee and North Carolina, **John W. Goodwyn** has been appointed sales representative for the United States Graphite Co. of Saginaw, Mich. His headquarters will be in Chattanooga, Tenn.

♦

Vice president of Laminated Plastics Inc. for the last two years, **Edward W. Hollis** has been named manager of the rubber division, Parker Appliance Co., Cleveland. **D. W. Holmes,** general sales manager, has assigned the additional responsibilities of managing rubber sales to **E. L. Carlotta,** the division's research and development engineer. **Don C. Pierce Jr.,** for the last year sales manager for Cleveland Republic Tool Corp., has joined the company as a rubber sales engineer.

♦

The appointment of **John D. Cook** as a representative in the north Indiana area has been announced by Kennametal Inc., Latrobe, Pa. At the same time it was announced that **William J. Bruun** and **Harry E. Brandvik** have joined the Chicago office, and **Edward J. Novack** has been added to the Philadelphia office of the company.

♦

New director of research for the Beryllium Corp., Reading, Pa., is **Gordon F. Simons,** who has been associated with the company in process development and production research. His recent activity in sales brings to the research department a thorough knowledge of present customer requirements and of industry demands for new beryllium alloy applications. **W. Thomas Peterson,** who succeeds Mr. Simons as general sales manager,

(*Continued on Page* 185)

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Against
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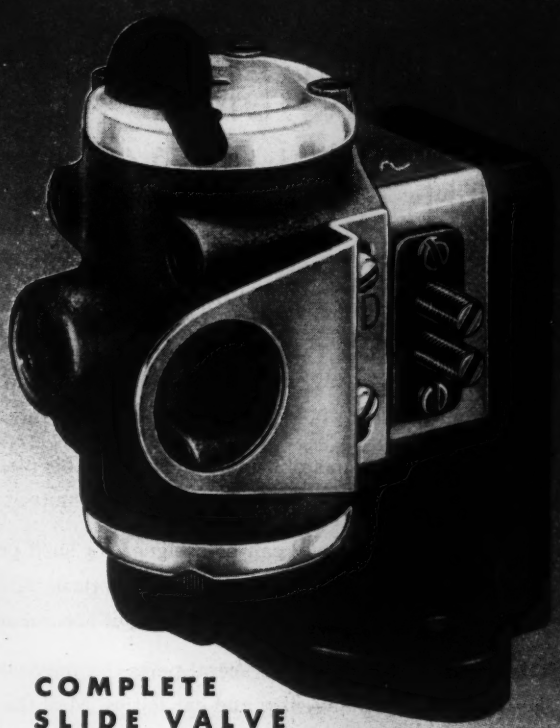
AIR VALVE



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SLIDE VALVE
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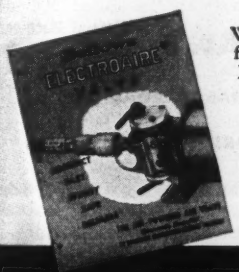
The Bellows Electroaire Valve is a complete "packaged" air control unit, consisting of a four-way directional slide valve, solenoid controls, and piston speed regulators.

Designed to eliminate costly "down time" caused by power solenoid failures, the Bellows Electroaire Valve is unconditionally guaranteed against solenoid burnout.

Solenoid-controlled, *but air-powered,* the ELECTROAIRE Valve is compact to allow installation in crowded quarters; tiny as compared to solenoid powered valves of similar capacity. It's bullet fast, yet quiet and shock-free. It's simple in principle and construction, but packed with power. Thoroughly proven by successful use of thousands of units under exacting operational conditions by America's smartest production men.

Compact, safe, fast, reliable, the Bellows Electroaire Valve is guaranteed insurance against costly "down time" caused by solenoid burnout.



Write for this valuable free booklet today. Read how simply you can convert your air-powered equipment to fast, safe, guaranteed electrically-controlled operation. *Address The Bellows Co., Dept. MD 550, Akron, Ohio.*

● The Bellows Electroaire Valve is an integral part of the Bellows Air Motor (the air cylinder with the built-in valve and speed controls) and of all Bellows "Controlled-Air-Power" devices arranged for electrical operational control. It is available, as illustrated above for direct connection to, or remote control of any air cylinder, up to eight inches in size.

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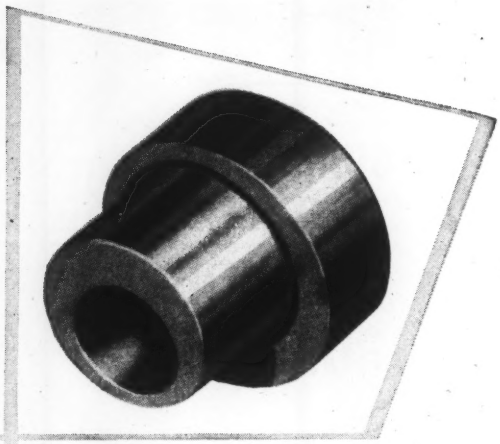

This feed raising cam for sewing machines is produced from iron sintered powder with close tolerances throughout. Made by the Wel-Met Company, Kent, Ohio, it is oil-impregnated for permanent lubrication. The hole is off center, but this is no problem for powder metallurgy.

Originally, the part was machined from bar stock, and it was extremely difficult to hold the required close tolerances.

Powder metallurgy production of this piece eliminated machining and finishing, and waste material. In addition, longer life for the part and reduced costs were realized.

Parts made from powder metal can be designed for such properties as high tensile strength, hardness, ductility, corrosion resistance, self-lubrication, controlled porosity, or a combination of several such factors.

Stokes does not make powder metal parts . . . only powder metal presses in many sizes and capacities. Mail the coupon for "Two Dozen Years in Powder Metallurgy" . . . it tells what Stokes offers you in determining if powder metallurgy is a practical process for your parts production.

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(Continued from Page 182)

has been a sales engineer in the automotive industry for over twenty years and has represented the Beryllium Corp. in the Detroit area for several years.

♦

Thomas P. Gallagher has been named assistant sales manager of Munray Products Inc., 12400 Crossburn Ave., Cleveland, O. This company sells corrosion resistant materials and equipment, organic coatings, industrial finishes, adhesives, process equipment linings and moldings and extruded products manufactured by the Poly-Cyclo Products Co.

♦

Allied Control Co. Inc. has appointed **G. E. Harris,** Administration Bldg., Municipal Airport, Wichita, Kans., to handle sales of their electrical relays in the state of Kansas and the western half of Missouri.

♦

New assistant manager of sales for the welded tube division of the Babcock & Wilcox Tube Co. is **John A. Menster,** who has been with the company since 1943. He will continue to make his headquarters in the general sales office, welded tube division, of the company in Alliance, O. It was also announced that **C. B. Marshall Jr.** has been appointed to the sales force of the Chicago district sales office. His headquarters will be at the company's offices in the Borland Bldg., 105 South LaSalle St., Chicago, Ill.

♦

Formerly employed by Armour Research Foundation in Chicago as supervisor of abrasion research, **Roy D. Haworth Jr.** has been appointed manager of product development of the carbide alloys division of Allegheny Ludlum Steel Corp. He will be located at the division's headquarters and plant at Ferndale, Mich.

♦

The Cambridge Wire Cloth Co. has announced that **J. C. Peters** has been assigned to the New England territory. He will maintain offices at 141 Milk St., Boston, Mass., and 551 Fifth Ave., New York City.

♦

Appointment of **T. J. Roberts** as Houston, Tex., district manager of the Johns-Manville industrial products division was announced recently. Mr. Roberts had been Atlanta district manager for the division and is succeeded in that position by **Henry G. Palmer,** former assistant manager in Atlanta. Mr. Roberts will supervise sales in Texas and parts of

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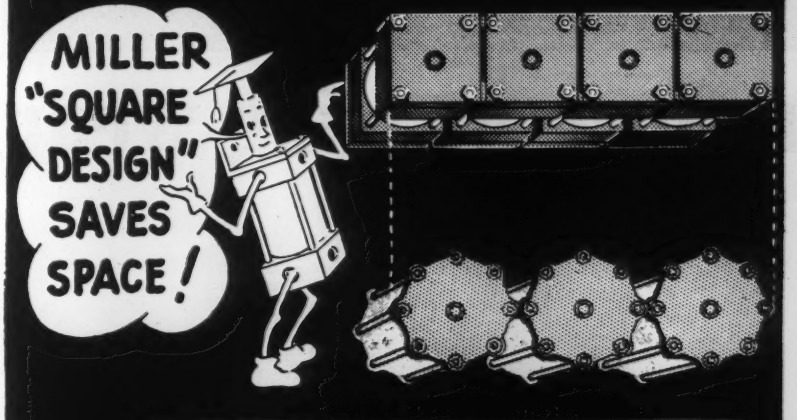
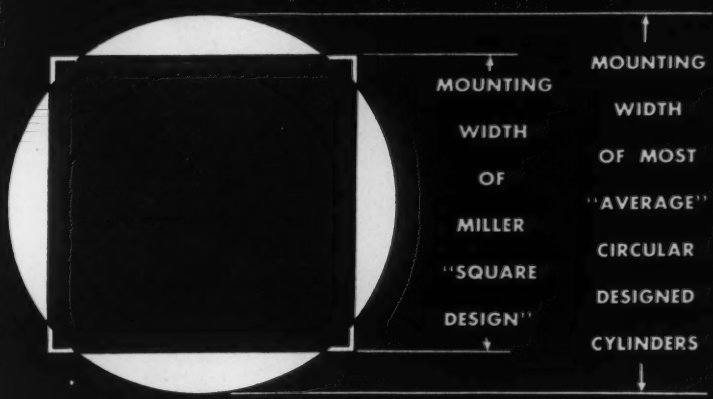
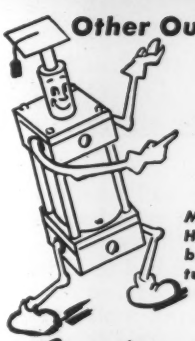
MILLER "SQUARE DESIGN" SAVES SPACE!





Other Outstanding Miller Standard Features . . .



- SOLID STEEL HEADS, CAPS, MOUNTINGS. Eliminate breakage.
- HARD CHROME PLATED PISTON RODS. Resist nicks, scoring.
- DIRT WIPER SEALS. Keep out abrasive dirt.

Miller High Pressure Hydraulic Cylinders meet the "J. I. C." Hydraulic Standards, the "quality" standards recently approved by the Joint Industry Conference (J. I. C.) of leading manufacturers and users of hydraulic equipment.

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- LOW PRESSURE HYDRAULIC CYLINDERS 1½" to 14" Bores
- HIGH PRESSURE HYDRAULIC CYLINDERS 1½" to 12" Bores

Single and Double Acting, Single and Double Rod End, Spring Return, Cushioned and Non-Cushioned, Over-Sized Rod, and Long Stroke Cylinders in All Mounting Styles.

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Miller Air Cylinder Bulletin A-105 and Miller Hydraulic Cylinder Bulletin H-104

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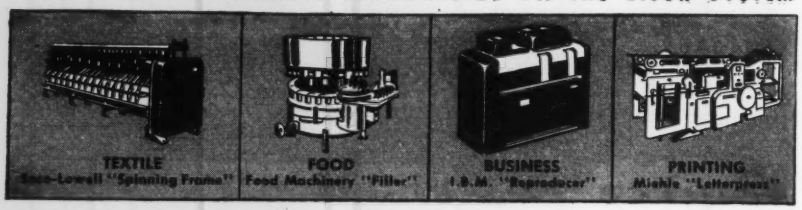
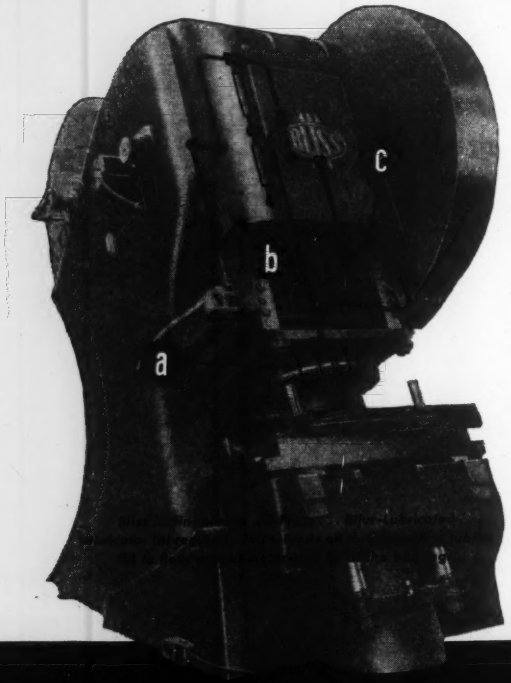
LEADING MANUFACTURERS STANDARDIZE ON THE BIJUR SYSTEM



reduce bearing wear



by controlling oil film at the bearings

Oil film at the bearings keeps the metallic surfaces apart, reducing wear to a minimum. This oil film must be maintained *constantly* to be effective.

Lubrication by hit and miss methods can't be depended upon to keep bearings running smoothly. Proper lubrication requires a system which force-feeds the correct amount of oil to all bearings and carefully controls the oil flow at each individual bearing *automatically.*

This is accomplished by Bijur, the system with positive Meter-Unit control of oil flow *at the bearings.* For further details write for "The A B C of Modern Lubrication."

387

The correct oil film to each individual bearing... automatically

BIJUR
LUBRICATING CORPORATION

LONG ISLAND CITY 1, NEW YORK

Louisiana, Arkansas and Oklahoma, and Mr. Palmer will cover the territory of Georgia, Florida, Alabama, South Carolina, and parts of Kentucky, Mississippi, North Carolina, Tennessee and Virginia.

♦

Industrial sales manager since 1948, **George F. Jenkins** has been made sales manager of the National Screw & Mfg. Co., Cleveland. He succeeds, in active sales direction, **B. H. Jones,** veteran vice president of sales, who under that title will continue in advisory capacity in sales activities of National, its California subsidiary, and divisions including Hodell Chain Co. of Cleveland and Chester Hoist Division of Lisbon, O.

♦

E. A. Johnson has been elected vice president in charge of sales for the Barry Corp., Cambridge, Mass., manufacturers of shock mountings and vibration isolators.

♦

It was announced recently that **F. S. Jones** has been elected vice president in charge of sales for the Colorado Fuel and Iron Corp., Denver, Colo. He succeeds **Newell H. Orr,** who has retired but who will continue in an advisory capacity. Mr. Jones and **James N. Counter,** who replaces him as general manager of commercial steel sales of the western division, will be located at the general offices of the company in Denver.

♦

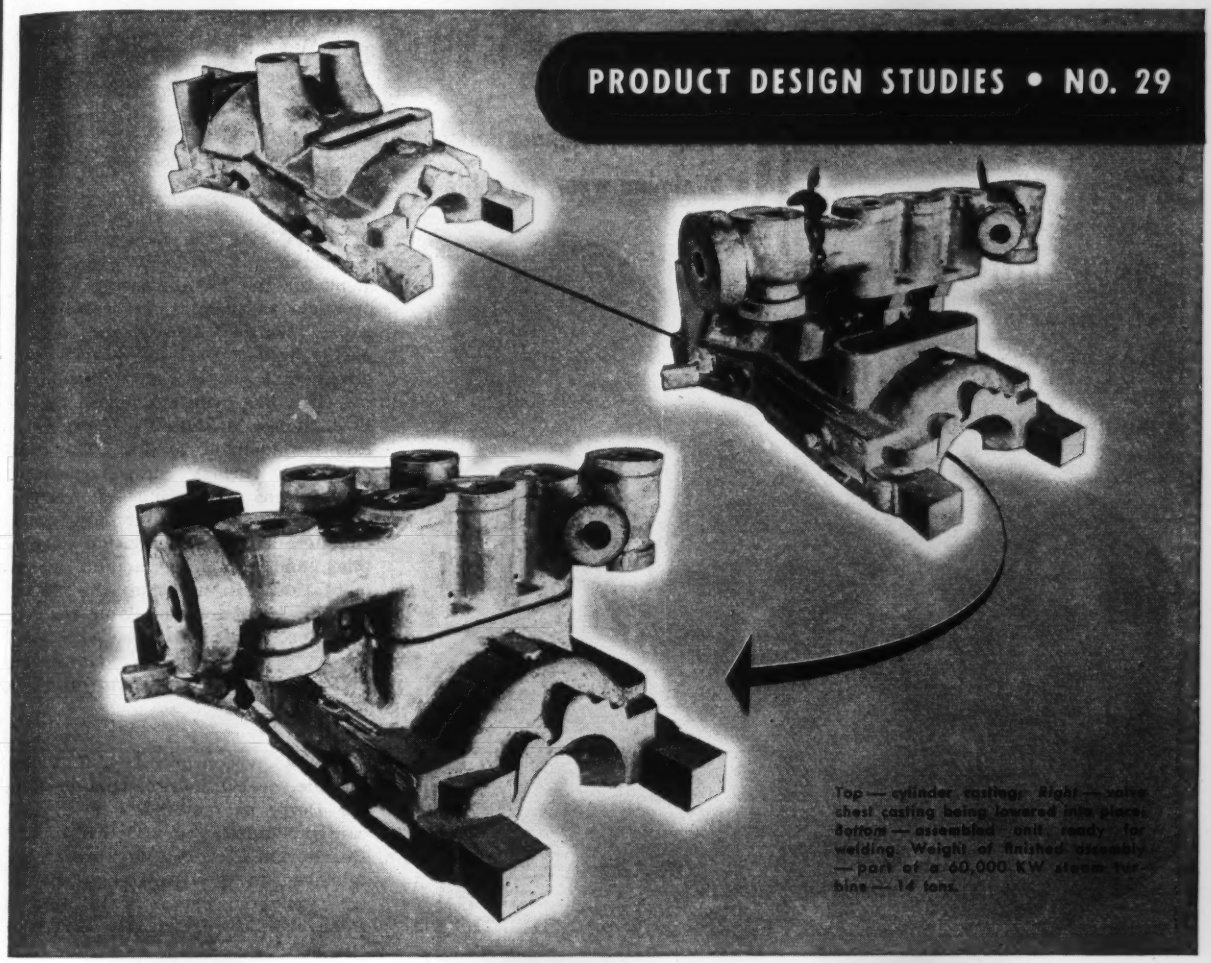
New sales engineering representative for Aurora Metal Co., Aurora, Ill., is **A. W. Pollard,** Case Bldg., 82 St. Paul St., Rochester 4, N. Y. His territory includes New York State exclusive of the metropolitan New York City area.

♦

J. Allison, formerly of A. C. Geldner & Co., has been appointed sales representative for the states of Oregon and Washington by Titan Metal Mfg. Co., Bellefonte, Pa., manufacturers of brass and bronze rods, extruded shapes, forgings, and die castings. He has an office at 203 White-Henry-Stuart Bldg., Seattle, Wash., and another at 614 Medical Arts Bldg., Portland, Ore.

♦

Well known in the radio-electronic trade, **Henry D. Sarkis** has been appointed sales representative for the Clarostat Mfg. Co. Inc., Dover, N. H. He will cover the industrial accounts in metropolitan Chicago and metropolitan Milwaukee areas, working out of his heaquarters at 6459 Sheridan Rd., Chicago, Ill.


PRODUCT DESIGN STUDIES • NO. 29
Top — cylinder castings. Right — valve chest casting being lowered into place. Bottom — assembled unit ready for welding. Weight of finished assembly — part of a 60,000 KW steam turbine — 14 tons.

Value Of Restudy Of Existing Designs Shown In *Steel Castings* For Turbines

• It has been standard practice, until recently, to produce the cylinder and valve chest for steam turbines as a single steel casting.

With greater demands on this part because of higher operating temperatures and increased unit capacity, steam turbine manufacturers by necessity developed a more complicated design. Keeping abreast of this change, the steel foundry suggested a way to maintain quality standards and at the same time effect a substantial savings, which was passed on to the customer in the form of reduced pattern costs.

Since cast steel is readily weldable, the foundry engineers suggested redesign of the part to cast-weld construction — a cylinder casting and a valve chest casting joined together by welding.

Proof of customer satisfaction is the fact that this redesign will be standard.

* * *

Here is another example of the engineering teamwork in design and redesign of parts which today is resulting in substantial savings and greater serviceability with steel castings. This service is available to your company without cost or obligation.

STEEL FOUNDERS' SOCIETY OF AMERICA
920 Midland Building — Cleveland 15, Ohio

Design and Build With Steel Castings

ORANGE
Cage Type NEEDLE BEARINGS
meet critical needs of spindle shank mountings in
POTTER & JOHNSTON
Multiple Spindle Drill Heads

- Minimum space
- High precision
- Simplified, compact design
- Minimum wear, long life

The P & J self-driven Multiple Spindle Drill Head—operating directly from the turret of P & J Automatics—drills, countersinks or reams any number of holes to precision specifications for size, location and alignment, all in one holding. Action, including feed, is fully automatic.

● Wherever you require bearings for spindles—high speed applications—or vertical operation, Orange Cage Type Needle Bearings are the ideal bearings. All rollers are held in permanent alignment by a free-floating, land-riding cage made of anti-friction, non-ferrous metal, which prevents skewing while running. Pockets are coined to contour of rollers. Internal clearances can be accurately controlled to meet exacting requirements. These features also permit successful installation in overhung mountings and minimize the effects of mis-aligned mountings.

All rollers and races "Pentrate" finished for corrosion resistance and reduced friction. Extremely smooth, quiet running, with longer life expectancy. Write for Engineering Data or consult our field representative.

ORANGE

ORANGE ROLLER BEARING CO., INC.
556 Main Street, Orange, N. J.

SALES NOTES

ENTRY into the field of vacuum metallizing, with complete equipment for the metal coating of such products as plastics, crystals, glass, paper, textiles, lenses and optical parts, light reflectors, jewelry and ornamental pieces, automotive insignia, etc., has been announced by the **F. J. Stokes Machine Co.**, 5900 Tabor Rd., Philadelphia 20, Pa. The company will furnish complete-package installations consisting of vacuum chambers, vacuum pumping units, complete product mounting assemblies, and complete vacuum instrumentation. In addition, the Stokes advisory service is available for consultation, technical assistance and service in pretreatment, coating, and after-treatment of various products.

♦

Now a division of the **H. K. Porter Co. Inc.** of Pittsburgh, **Quaker Rubber Corp.** has opened a new stock carrying branch at 311 First Ave., Pittsburgh, Pa. The new branch, established to give greater service to all Quaker's customers in western Pennsylvania, eastern Ohio and West Virginia, will carry a complete inventory of industrial rubber products and is under the direction of H. M. Sossaman, who was formerly assistant general sales manager for Quaker.

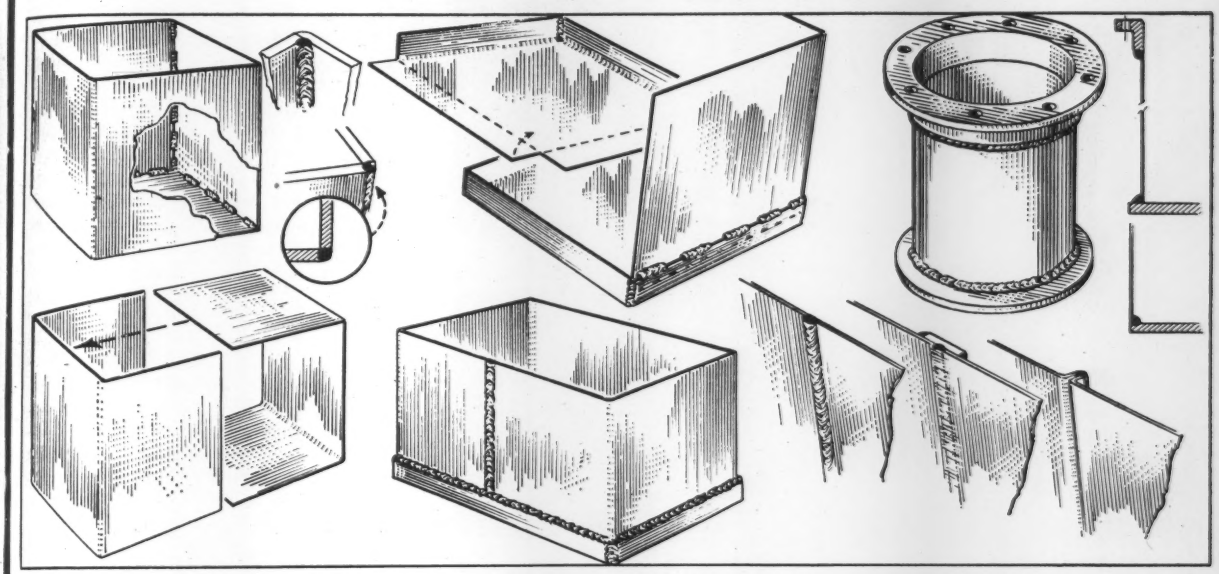
♦

The **Paquin Co.**, 145 East 192nd St., Cleveland, O., was recently appointed exclusive sales and service representative for industrial division products in northern Ohio for **Greer Hydraulics Inc.**

♦

As part of its extensive research program, **Steel Founders' Society of America** has initiated a special project to investigate and evaluate all known information on the removal of excess metal normally developed in the production of steel castings. While there have been noteworthy advances in recent years, the project recognizes the limited nature of existing data on varying methods of metal removal for gates, risers, feeding pads, fins and other minor protuberances normally encountered. In seeking more complete comparative information

Looking for Ways to Simplify Design and Cut Costs of Machine Parts?

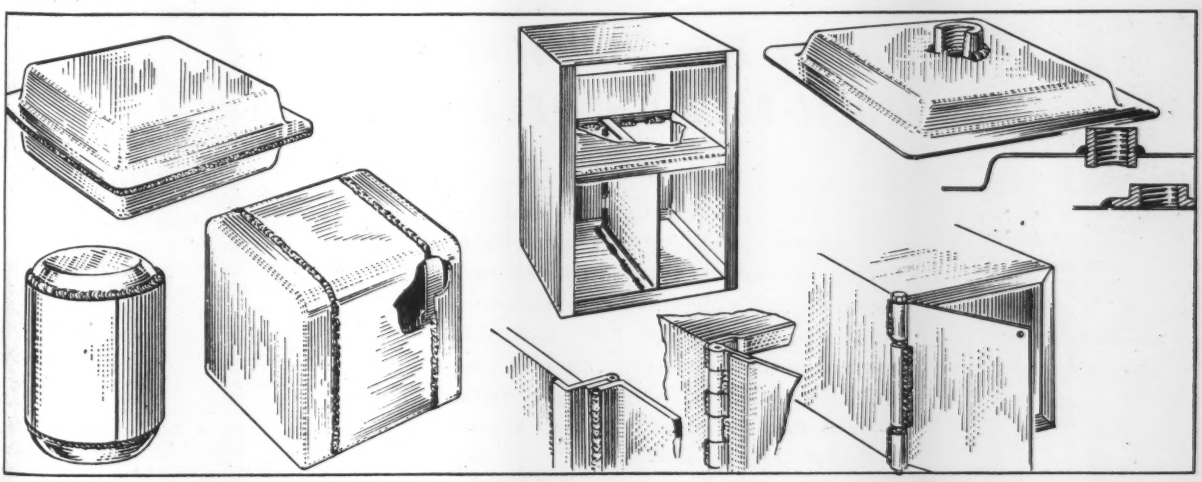


Containers and covers for machinery built simpler, yet stronger, lighter and at lower cost with arc welding.

HERE are some thought starters on how typical machinery parts like containers and covers can be built stronger, lighter and at lower cost with arc welding. Shop fabricating methods are also greatly simplified since component parts are sheared and formed from sheet steel, then held in simple clamp type fixtures and arc welded.

Through the use of arc welded design, it becomes possible to eliminate many machining operations formerly needed with other methods. With welded construction, less material is required, thus reducing the weight of operating parts.

Arc welding produces solid, one-piece construction to give dependable, trouble-free service. It eliminates all possibilities for loosening of joints as in riveted design.



THOUGHT STARTERS FOR MACHINE DESIGN

For "Thought Starters on Welded Design", available to engineers and designers upon request on your letterhead, write

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Sales Offices and Field Service Shops in All Principal Cities

LINCOLN

BALANCED ARMATURE
for vibration resistance

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for shock resistance

55% MORE COIL VOLUME
for lower wattage

TWIN AIR GAP
for maximum magnetic efficiency

STRUTHERS DUNN
5,348 RELAY TYPES

Military Type MINIATURE MULTI-POLE D-C RELAY

Here are miniature, low wattage d-c relays that really stand up under extreme conditions of shock and vibration. False contact operation is avoided without sacrificing desirable electrical characteristics —and at no extra relay cost. Available in any contact arrangement up to 4-pole double-throw. Open, plug-in base, metal encased or hermetically-sealed types. Write for Bulletin L2610.

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BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI CLEVELAND • DALLAS • DETROIT • KANSAS CITY • LOS ANGELES • MINNEAPOLIS • MONTREAL • NEW ORLEANS • NEW YORK • PHILADELPHIA • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

based on actual operating experience, restudy of all established methods will be made, together with independent investigation of latest developments in the field.

♦

The appointment of the **Austin-Hastings Co. Inc.** as district representative for the states of Maine, Vermont, Massachusetts, New Hamphire, Connecticut and Rhode Island has been announced by the **Federal Machine and Welder Co.** The Austin-Hastings Co. is located in Cambridge, Mass., with branch offices in Hartford, Conn. and Worcester, Mass. John Argento, manager of the welding division, will operate from the Cambridge office, with sales engineers working out of the other two offices.

♦

A district office and warehouse has been opened in the new Singer Bldg., 5900 Second Blvd., Detroit 2, Mich., by the **Diehl Mfg. Co.**, Electrical Division of the **Singer Mfg. Co.** The new office is under the management of James E. Ryan.

♦

The gear sales division of **Farrel-Birmingham Co. Inc.**, which has been located in Buffalo and the marine sales division, formerly connected with the New York office, have been moved to the company's main offices at Ansonia, Conn. These moves are in line with the company's policy to co-ordinate and centralize, as much as possible, various departmental functions.

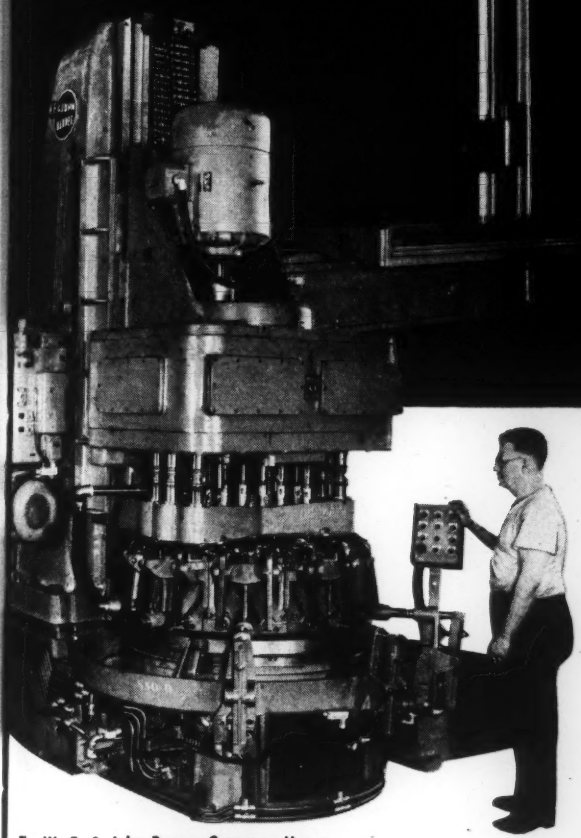
♦

Jenkins Bros., manufacturer of valves, rubber and insulating tapes, etc., has recently moved its New York office from 80 White St. to 100 Park Ave., New York 17, N. Y.

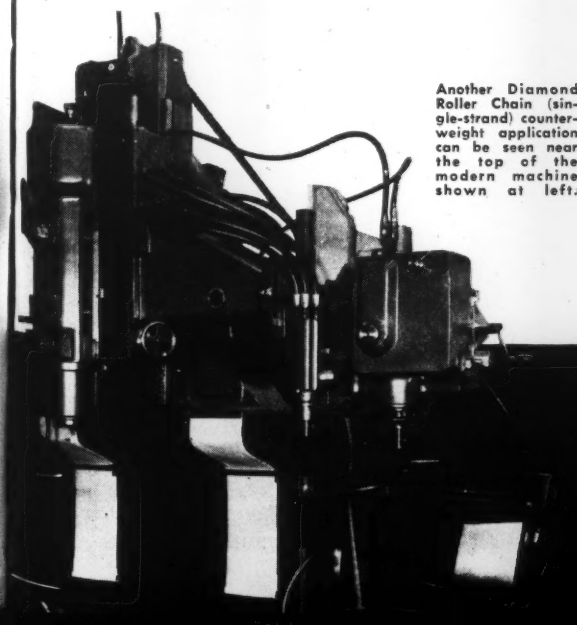
♦

In order to increase the availability of aluminum and to better serve small users, **Reynolds Metals Co.** aluminum division has recently appointed seven new distributors. Four new distributors handling the general line of Reynolds aluminum mill products, including sheet, plate, wire, rod, bar, and extruded shapes are: **Mutual Mfg. & Supply Co.**, 2901-33 Spring Grove Ave., Cincinnati 25, O., covering the territory of Ohio north to Columbus, eastern Indiana, northeastern Kentucky and the West Virginia Valley; **American Steel & Alloys Corp.**, 425 Homestead Ave., Hartford 5, Conn., covering Connecticut and Rhode Island; **Merchant & Evans Co.**, 2035 Washington Ave., Philadelphia, Pa., with the territory of Pennsylvania, Delaware, northern Mary-

FOR GREATEST SAFETY IN COUNTERWEIGHT SERVICE



The W. F. & John Barnes Company Heavy-Duty Vertical Machine employs Diamond triple Roller Chain in counterweight service.



Another Diamond Roller Chain (single-strand) counterweight application can be seen near the top of the modern machine shown at left.

DIAMOND Roller Chains

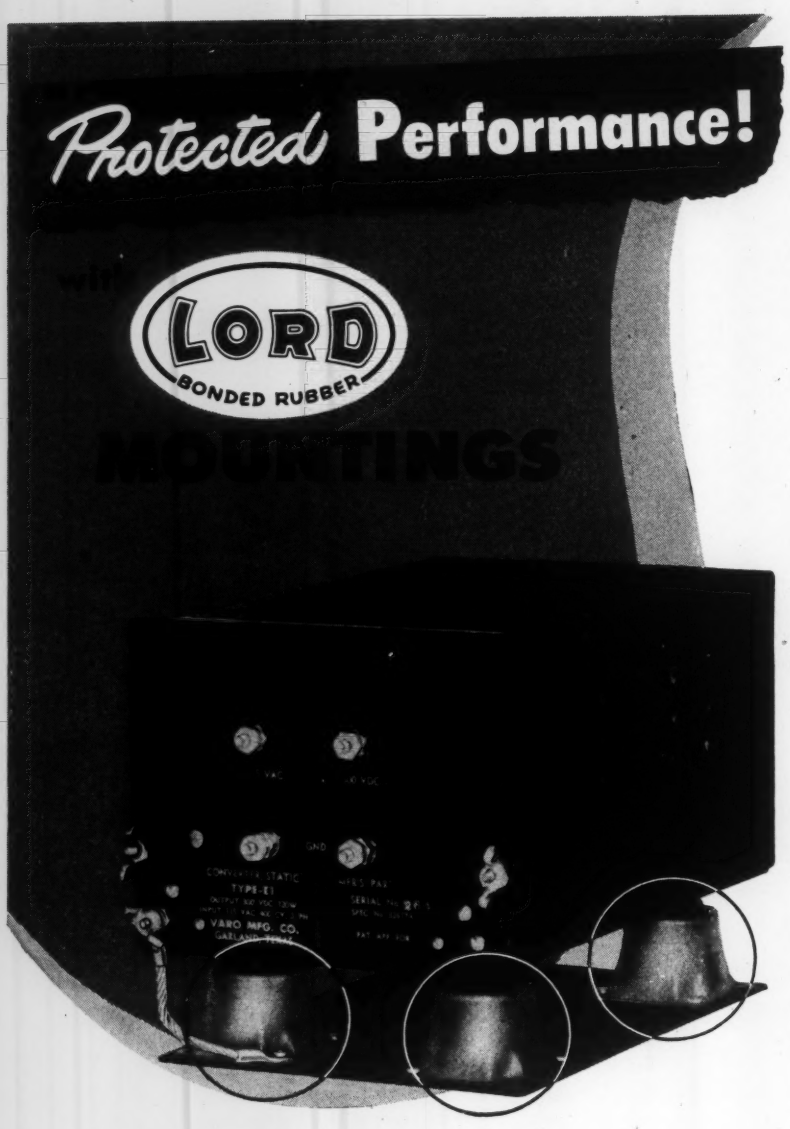
• For counterweight service, where the ultimate in safety for operator and machine is so essential,—the reliability of Diamond Roller Chains has long been recognized by machine tool builders and users.

Joint articulation is sustained by diameter-ground case hardened alloy steel pins in case hardened alloy steel bushings. The pins are press-fit in pin link plates;—the bushings, in roller link plates preventing relative motion of link plates and the round parts.

Strength and durability are maintained, — elongation minimized — accuracy and positive operation assured. For the ultimate in safety, Diamond Roller Chains should be your choice, too.

DIAMOND CHAIN COMPANY, Inc., Dept. 435, 402 Kentucky Avenue, Indianapolis 7, Indiana.

Offices and Distributors in all principal cities.



Varo Static Converters change alternating to direct current for aircraft use with *less than 1% voltage ripple.* LORD Mountings protect such precision against shock and vibration, thus insuring the user long and dependable service.

More and more manufacturers of sensitive equipment appreciate the customer satisfaction which LORD Vibration-Control Mountings add to their products. Builders of heavier mechanical equipment use them to provide smoother, quieter operation . . . greater sales appeal. If you are interested in product improvement, investigate LORD Mountings now.

LORD BONDED RUBBER **Vibration Control**

LORD MANUFACTURING COMPANY · ERIE, PA.

Canadian Representative: Railway & Power Engineering Corp. Ltd.

land and New Jersey; and **Athos Steel Service Co.,** Fifth and Butler, Philadelphia, Pa., serving the Philadelphia area. **Potts-Farrington Co.** is still active in this district also. In addition, high purity pig and ingot, as well as other ingot products, will be available through the following new distributors: **Silverstein & Pinsoff Inc.,** covering the Chicago area, all of Wisconsin, southern Michigan, northern Indiana and eastern Iowa; **Rochester Smelting & Refining Co.,** P. O. Box 547, Rochester, N. Y., serving the Rochester and Buffalo, N. Y. areas; and the **Atlas Metal Co.,** 2651 East 76th St., Cleveland, O., covering the Cleveland area.

♦

Opening of an eastern sales office for the **Shakeproof Inc.** division of **Illinois Tool Works** was announced recently. The new office, located in the Chrysler Bldg., 405 Lexington Ave., New York, N. Y., will be headed by Russell W. Bill, newly appointed eastern sales manager. He will direct the activities of Shakeproof's sales staff covering the territory from Pittsburgh to the Atlantic coast.

♦

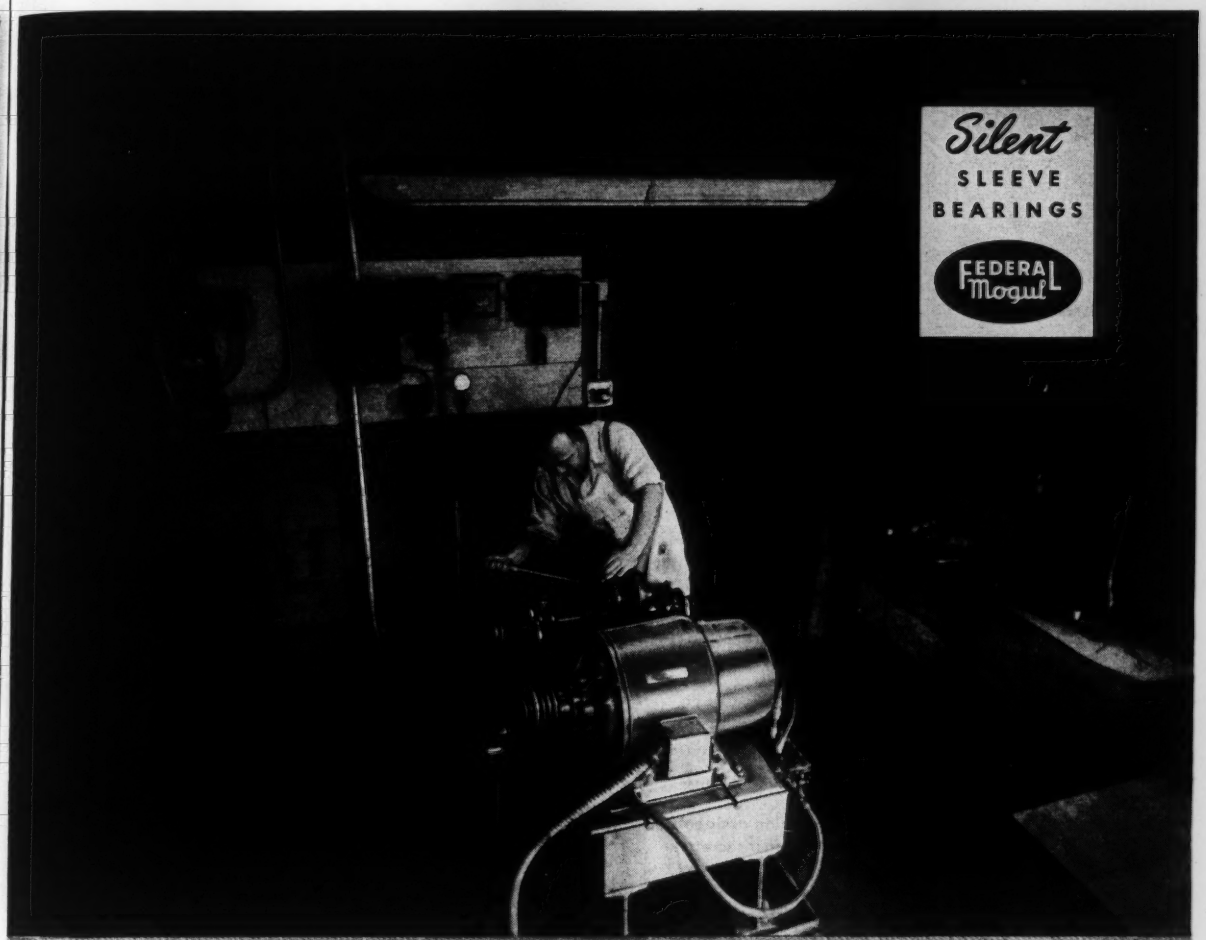
Two additional electrical division sales offices have been established by **Wagner Electric Corp.** of St. Louis. The New Orleans office, a sub-branch of St. Louis sales under the direction of N. G. Alvis, is located at 227 International Trade Mart. The Davenport office, located in the Kahl Bldg., is under the direction of S. R. Snyder and is a sub-branch of Chicago. The two additions will provide more convenient field engineering service for users of Wagner electrical apparatus in these areas.

♦

Three sales representatives were recently appointed by **Trabon Engineering Corp.,** manufacturer of oil and grease lubricating systems. The firms appointed are **Kendall Engineering Sales Co.** of Milwaukee, representative for Wisconsin; **Grant Watson Construction Co.** of Denver for Colorado and Wyoming; and **Engineering Associates,** Omaha, for Nebraska and South Dakota.

♦

In order to further expand its services to customers throughout the East and to speed up deliveries in that area, **Chiksan Co.** of Brea, Calif. is establishing a warehouse stock in the Federal Storage Bldg., 155 Washington St., Newark 2, N. J. Eastern headquarters for the company and the **Chiksan Export Co.** are also being transferred from 50 Church St. in New York to the Newark address.



Sleeve Bearing Torture Chamber

Here, bearings are given really brutal tests. In just a few hours, they get a tougher workout than they would get in years of normal service. This "third degree" treatment makes any bearing tell all about its performance capabilities.

Can it stand high heat? . . . heavy load? . . . high speed? . . . pounding? . . . The research engineer answers all of these questions, and more.

Because he knows that there is no *universal* bearing material, the research engineer must establish fields of usefulness for many bearing alloys. Working within the limits of each, he specifies which will be best for the particular set of operating conditions to be met.

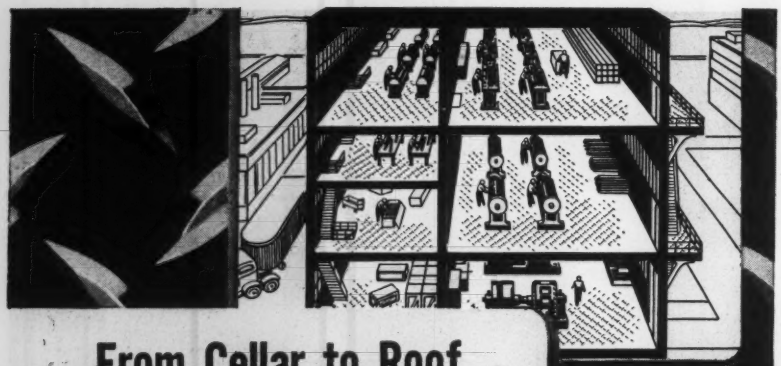
He has the answers to questions that may not be asked by the engine builders for several years. This is as it should be. The research engineer must think ahead, plan ahead, and have tomorrow's sleeve bearings ready today!

Our engineers have had millions of dollars' worth of experience—take advantage of it in *your* sleeve bearing requirements!

FEDERAL-MOGUL

Federal-Mogul Corporation
11045 Shoemaker, Detroit 13, Michigan

OVER FIFTY YEARS OF CONTINUOUS BEARING EXPERIENCE



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MEETINGS AND EXPOSITIONS

May 19-20—

Institute of the Aeronautical Sciences. Seventh annual personal aircraft meeting to be held at Lassen Hotel, Wichita, Kansas. Robert R. Dexter, 2 East 64th St., New York 21, N. Y., is secretary.

May 25-27—

Society for Experimental Stress Analysis. Spring meeting to be held at the Hotel Statler, Cleveland, Ohio. W. M. Murray, Central Square Station, Cambridge 39, Mass., is secretary-treasurer.

May 29-June 9—

Canadian International Trade Fair to be held at Toronto, Canada. Additional information may be obtained from the International Trade Fair, Exhibition Grounds, Toronto, Canada.

June 1-2—

American Society for Quality Control. Fourth national convention and fifth Midwest conference to be held in Milwaukee, Wis. Additional information is obtainable from Fourth National Convention, Fifth Midwest Conference, P. O. Box 1204, Milwaukee, Wis.

June 4-7—

American Society of Refrigerating Engineers. The 37th spring meeting to be held at Hotel Muehlebach, Kansas City, Mo. David L. Fiske, 40 West 40th St., New York 18, N. Y., is secretary.

June 4-9—

Society of Automotive Engineers. Summer meeting to be held at French Lick Springs Hotel, French Lick, Ind. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

June 5-7—

American Gear Manufacturers Association. Annual meeting to be held at the Homestead, Hot Springs, Va. Newbold C. Goin, Empire Bldg., Pittsburgh 22, Pa., is executive secretary.

June 11-16—

American Electroplaters' Society. 37th annual convention to be held at Hotel Statler, Boston, Mass. Fourth International Electrodeposition Conference in collaboration with the Electrodepositors' Technical Society of

A section of the engineering department—The Heald Machine Company, Worcester, Mass.

"Now...we get photographic intermediates quickly, economically"

reports

THE HEALD MACHINE COMPANY

Since 1947 the production of photographic intermediates has been easier, faster, more economical for The Heald Machine Co. *Thanks to Kodagraph Autopositive Paper.*

With this revolutionary, low-cost intermediate material, positive photographic copies of original drawings are produced *directly*—without a negative step.

Furthermore, Heald uses its direct-process machine for the exposure operation; standard photographic solutions for development. And there's this convenience, too: darkroom handling is a thing of the past! Both operations are performed under ordinary room light.

How "Autopositive" is used: A large percentage of the precision finishing machines manufactured by Heald are specially engineered to customer-specifications. And, frequently, Heald is requested to draw special units and fixtures on the customer's own drafting paper. These originals are reproduced on "Autopositive" (for Heald's record) and turned over to the customer when the job is completed.

Thus, when repair parts are requested or a duplicate order is entered, shop prints can be made promptly from the Autopositives. These new intermediates have dense photographic black lines on an evenly translucent base . . . will not smudge or smear in print production . . . turn out sharp, clean prints at uniform, practical machine speeds.

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- **It enables you, or your blueprinter, to produce positive photographic intermediates *directly* . . . at a new low cost.**
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A new illustrated booklet, "Modern Document and Drawing Reproduction," gives all the facts on this revolutionary photographic intermediate material. *It's free. Just mail the coupon.*

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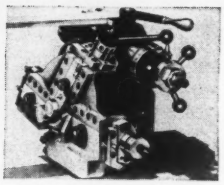
The only place to use a cheap screw is when you don't care if it holds or not. Usually shearing or loosening costs thousands of times what you "save" on the cheapest fasteners.

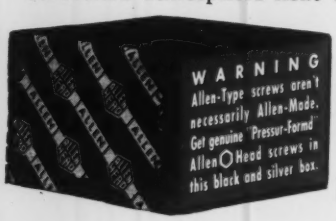
You pay no premium for *genuine* Allen Head screws—only enough to *assure* uniform strength and Class 3 fit.

Allen gives you the toughness of Allenoy steels, 100% Pressur-forming, the advantage of every proved threading method, quality control at every step, including automatic instrument controlled atmosphere heat treating.



This leading machine tool manufacturer uses Allen Head screws by the hundreds of thousands for compact design, assured holding power and maintenance of precision adjustments.

SOLD ONLY THROUGH LEADING DISTRIBUTORS
Write the factory direct for technical information and descriptive literature.


WARNING
Allen-Type screws aren't necessarily Allen-Made.
Get genuine "Pressur-Formed" Allen Head screws in this black and silver box.

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MANUFACTURING COMPANY
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England to be held concurrently. Additional information is obtainable from American Electroplaters' Society, 473 York Rd., Jenkintown, Pa.

June 12-16—

American Institute of Electrical Engineers. Summer and Pacific general meeting to be held at the Huntington Hotel, Pasadena, Calif. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

June 19-21—

American Society of Agricultural Engineers. Annual meeting to be held at the Statler Hotel, Washington, D. C. Raymond Olney, P.O. Box 229, St. Joseph, Mich., is secretary.

June 19-23—

American Society of Mechanical Engineers. Semi-annual meeting to be held at the Hotel Statler, St. Louis, Mo. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

June 19-23—

American Society for Engineering Education. Annual meeting to be held at the University of Washington, Seattle, Wash. Prof. Arthur B. Bronwell, Northwestern Technological Institute, Evanston, Ill., is secretary.

June 22-24—

American Society of Mechanical Engineers. Applied mechanics division conference to be held at Purdue University, Lafayette, Ind. C. E. Davies, 29 West 39th St., New York. N. Y., is secretary.

June 26-30—

American Society for Testing Materials. The 53rd annual meeting and ninth exhibit of testing apparatus and related equipment to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Robert J. Painter, 1916 Race St., Philadelphia 3, Pa., is assistant to the secretary.

July 12-14—

Institute of the Aeronautical Sciences. Annual summer meeting to be held in the Western Headquarters Bldg., Los Angeles, Calif. Additional information may be obtained from Robert R. Dexter, Secretary, 2 East 64th St., New York 21, N. Y.

Aug. 14-16—

Society of Automotive Engineers. West coast meeting to be held at the Biltmore Hotel, Los Angeles, Calif. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

FOR Hard-to-Start Jobs

Requiring Low Starting Current

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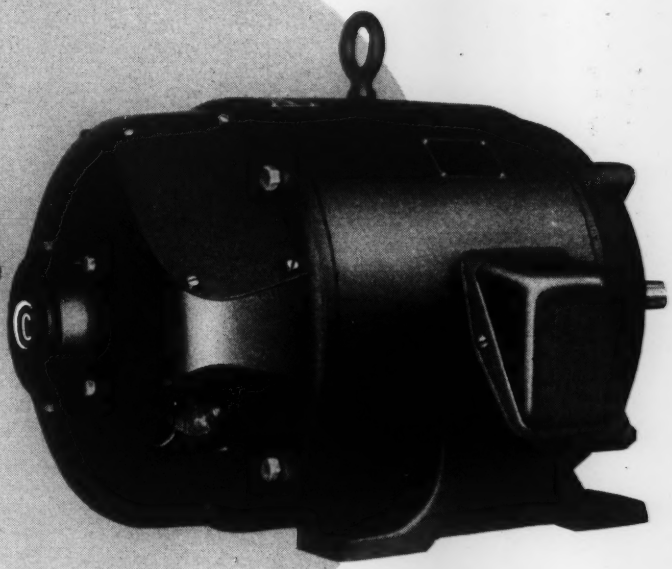
Century

TYPE RS*

MOTORS



** Single Phase, Repulsion Start, Induction, Brush Lifting Motors*

Century SERVICE

Is Near Any CENTURY Motor Driven Equipment

Satisfactory performance of CENTURY products is assured by more than 200 CENTURY Authorized Service Stations supervised by 28 CENTURY Sales Offices.

1. Facilities for immediate exchange of most CENTURY standard ratings of standard construction are available at CENTURY Authorized Service Stations.
2. CENTURY Authorized Service Stations are qualified and equipped to service and repair any piece of CENTURY apparatus.
3. Genuine CENTURY renewal parts are available at CENTURY Service Stations, CENTURY Parts Distributors and at the factory in St. Louis.

You will find that these rugged, dependable motors meet the starting, accelerating and running characteristics of such equipment as refrigeration compressors, air compressors, stokers, reciprocating pumps, and other hard-to-start loads.

For more than 47 years, Century Type RS motors have given satisfactory service throughout the world. They are available in sizes from ½ to 20 horsepower, in drip proof and splash proof frames.

In addition, Century builds electric motors in a wide range of types and kinds—in sizes from 1/6 to 400 horsepower for operation on single and polyphase and direct current. Specify Century motors for all your electric power requirements.

ALTERNATING CURRENT MOTORS

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Squirrel Cage Induction — 1/6 to 400 H.P
Wound Rotor Motors—1 to 400 H.P.
Synchronous Motors—20 to 250 H.P.

SINGLE PHASE

Split Phase Induction—1/6, 1/4, 1/3 H.P.
Capacitor—1/6 to 20 H.P.
Repulsion Start, Brush Lifting, Induction—1/2 to 20 H.P.

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1/6 to 300 H.P.

GENERATORS

AC, .63 to 250 KVA
DC, .75 to 200 KW

GEAR MOTORS

1/8 to 1-1/2 H.P.

MOTOR GENERATOR SETS

AC to DC, AC to AC
DC to DC, DC to AC

Open Protected, Splash Proof, Totally Enclosed Fan Cooled, Explosion Proof.

Ball Bearing motors are factory lubricated for several years' normal service. Bearing housing construction permits easy re-lubrication when unusual service demands it.

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CENTURY ELECTRIC COMPANY
1806 Pine St., St. Louis 3, Missouri
Offices and Stock Points in Principal Cities

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SHENANGO-PENN *Centrifugal* CASTINGS ... KEY TO SAVINGS

220-groove Fourdrinier wire cloth warp roll of alloy iron, shown during and after precision machining and grooving. Shenango-Penn centrifugal casting process gave highly desirable uniformity and extra *strength to avoid distortion in service due to weight of roll and tension of warp wires.*

NEED ROLLS?

Weigh these money-saving facts!

MORE and more industries and suppliers are turning to Shenango-Penn for rolls and roll assemblies because . . .

1. Shenango-Penn's carefully controlled centrifugal casting process, a natural for tough roll service, assures greater strength and uniformity, exceptionally fine pressure-dense grain, and freedom from blow holes, sand inclusions and other often hidden defects. It means much greater wear-life, less maintenance and replacement, plus ability to take abnormal loads and speeds without risking costly failure.

2. Shenango-Penn has the modern machining and finishing facilities, plus the years of specialized experience in producing quality rolls, that will meet your specifications with over-all precision. You save time and avoid trouble . . . both in installation and during subsequent use.

The big special roll shown and described above is one of the many varieties made by Shenango-Penn. For bulletins, for specific data on rolls or roll assemblies of *any* size or type, ferrous or non-ferrous, write to . . .

SHENANGO-PENN MOLD COMPANY
1285 West Third Street • Dover, Ohio
Executive Offices: Pittsburgh, Pa.

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All Bronzes • Monel Metal • Ni-Resist • Meehanite® Metal

DESIGN ABSTRACTS

Ceramics in Gas Turbines

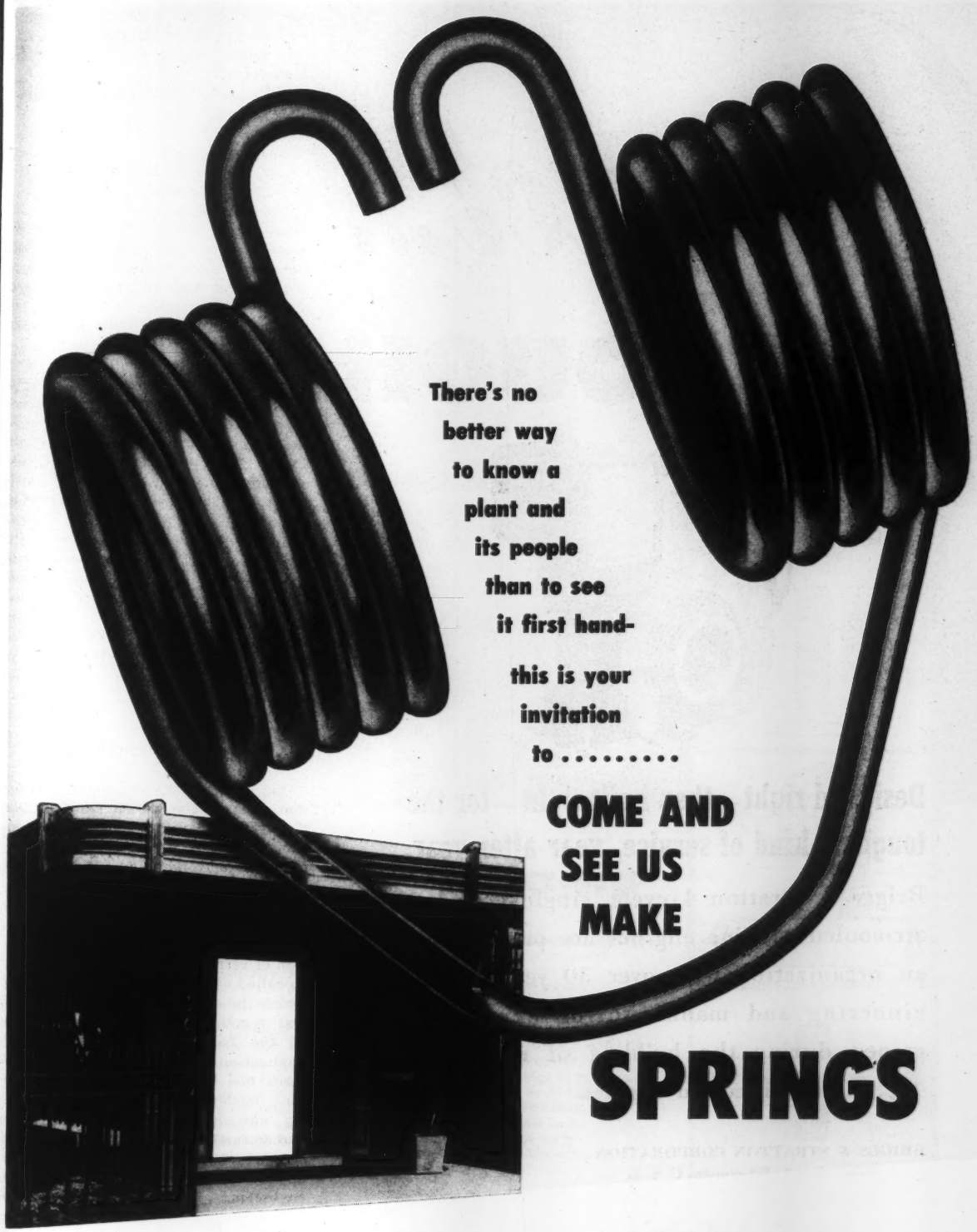
NEW heat-resistant materials are being developed continuously through ceramic research. Part of the research is directed specifically toward gas-turbine applications, and much of the remainder is in some way related to such uses.

Several ceramic bodies have higher ratios of tensile strength to density than the better commercial alloys at temperatures in the range of 1500 to 2200 F. Creep rates at 1800 and 1900 F apparently are adequate for oxide bodies. Oxidation problems and difficulties with wheel cooling may be encountered in the use of ceramic bodies with high thermal conductivities, while lack of sufficient thermal-shock resistance may limit seriously the use of low-conductivity bodies.

Service tests revealed certain problems in the use of the ceramic bodies. There were stress concentrations between wheel and blade when the ceramic blades were substituted directly in present metal designs. Severe thermal shock, resulting from failure of the air supply, caused fracture of blades in one instance. Mechanical-shock problems also were encountered. It is interesting to note that each shortcoming of the ceramic blades in these service tests is traceable to lack of ductility. If a ductile body exists, we are not aware of it.

Parts Prestressed in Compression

There is another consideration where close co-operation between ceramists and gas-turbine engineers might be beneficial. Ceramic bodies are inherently stronger in compression than in tension, as well as inherently brittle. The compressive strengths of some of the oxide bodies are of the order of 10 times their tensile strengths. This of course indicates that the best design would have ceramic parts either prestressed in compression, or subjected to compressive loads. Apparently, little has been done along this line. If suitable designs could be evolved, prestressing offers possibilities of reducing thermal and mechanical-shock problems, as failures from such shocks probably are basically tensile in nature. If on the other hand, the blades are subjected to compressive loads, porous



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its people
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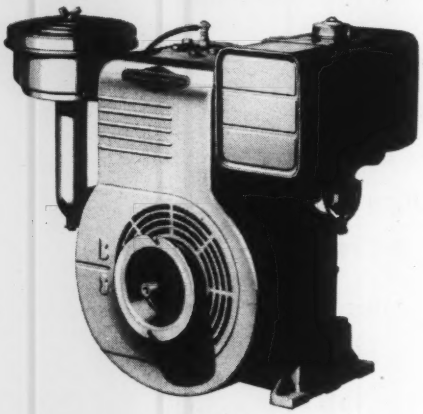

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bodies might be used. These bodies would have lower strengths, but better shock resistance than similar dense bodies.

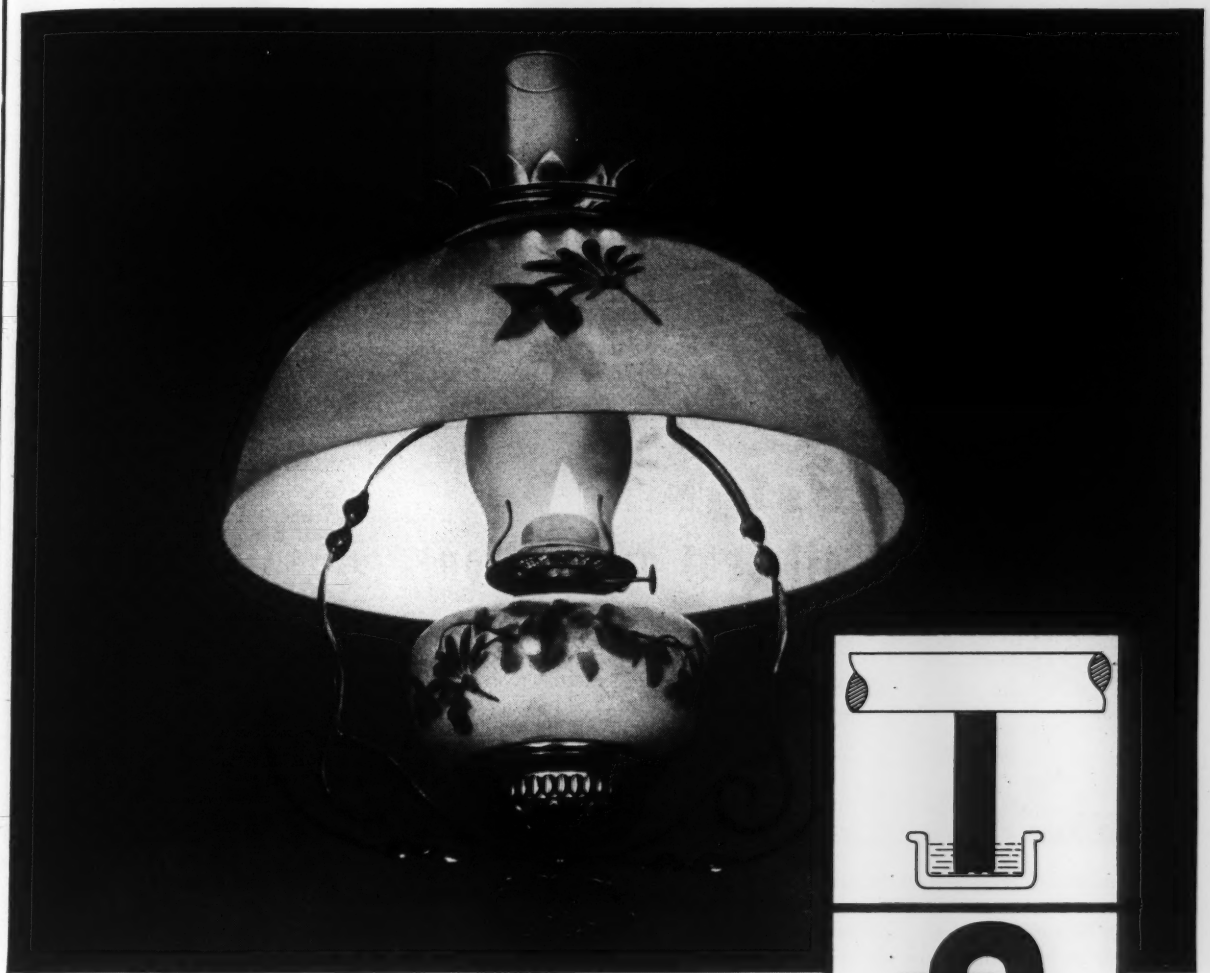
With lower mechanical requirements, stator blades offer a somewhat more likely future for ceramic bodies than rotor blades. Ceramic stator blades, made from bodies too weak for rotor blades, but with good thermal-shock resistance, might be satisfactory. Even without higher operating temperatures, it is possible that such blades would reduce weight and cost if used to replace metal blades in present designs.

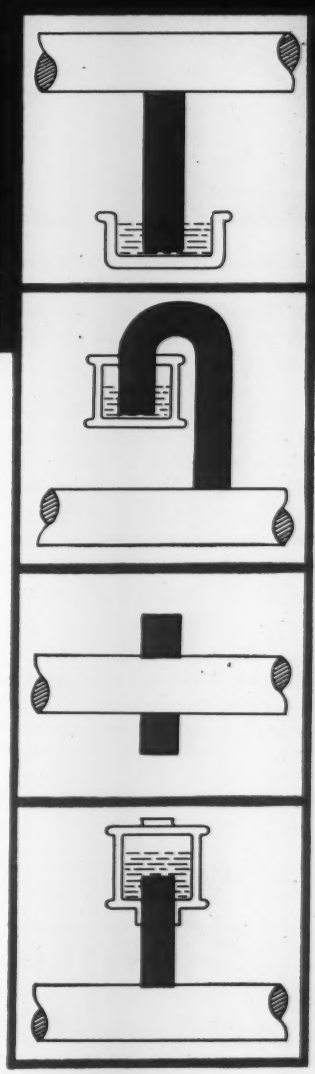
In addition to the work on ceramic bodies, a large portion of the ceramic research pertinent to gas turbines is directed toward developing and evaluating refractory ceramic coatings for metals. Such coatings seem particularly attractive for immediate use. They are not expected to afford outstanding benefits, but they are likely to extend significantly the usefulness of alloys, and few, if any, design changes are anticipated in order to use them. The primary purpose of the coatings, presumably, is to seal the metal surface against corrosive attack, and secondarily to provide thermal insulation. Not much can be expected from them as insulators as they must be thin in order to be tough and adherent.

Vapor-Deposition Process

As temperature requirements for materials of construction are pushed slowly but continuously upward by design engineers, attention is being given to new techniques for the application of refractory coatings not readily applied by conventional methods. The most generally useful methods developed to date for the formation of refractory coatings involve the so-called vapor-deposition processes in which the coating is formed by chemical reaction at the heated surface of the base material. Commercial application of vapor-deposition processes has been limited to materials for moderate-temperature service, e.g., chromized steels, siliconized iron, and so forth, but current research has shown promising results in several applications of interest to gas-turbine engineers.

Perhaps the outstanding development on vapor-deposition processes is the development of protective coatings for molybdenum which have permitted its use in air for over 5000 hr at 1800 F, and as long as 500 hr at 3100 F. In a number of tests for short-time applications in extreme high-temperature flames, molybdenum so protected has given outstanding





LIGHT from a lamp

Anyone who has ever used or seen a kerosene lamp or lantern knows how steady and clear the flame is, once the wick is correctly adjusted. The reason for this steady, smokeless and wasteless flame is that the wick feeds exactly the amount of oil required. Capillary action does the trick, plus correct wick type and adjustment.

Felt wicks can and do serve just as perfectly in lubrication. When correctly specified to meet the requirements of lubricant viscosity and delivery rate, they provide an accurately-metered quantity of oil to friction surfaces. It is not unusual for wick-lubricated bearings to serve without attention except at major overhauls; in other cases, re-filling of reservoirs at long intervals may be required. Felt wicks can be designed to deliver from a fraction of a drop per day, to many drops per hour; thus actual operating needs can be met. The basic source of wick lubrication technical data is American Felt Company's Data Sheet No. 6, "Wicks and Lubrication." Write for it today.

American Felt Company

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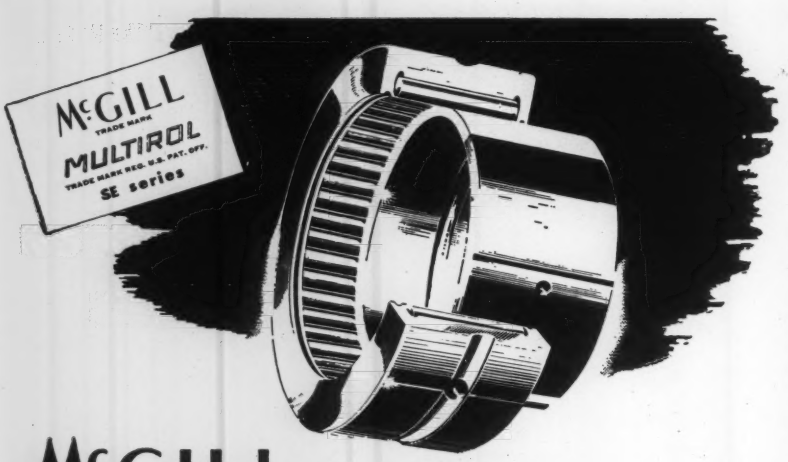

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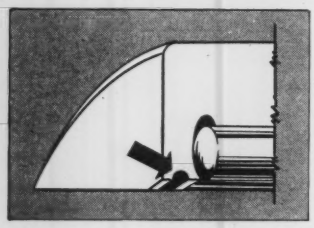


Extra protection against destructive foreign particles is provided by this lubricant-retaining groove, built into the inside diameter surface of the roller retaining-end shoulder. The ring of lubricant, held in this groove, acts against the inner race O.D., increasing the sealing effect of the precision tolerances between these shoulders and the inner race. Notice, too, the groove above the rounded end of the roller. Acting as a lubricant reservoir, this provides Multirol SE Series bearings with an extra margin of protection against neglected or delayed lubrication.

The increased life and lowered maintenance costs of Multirol bearings are accounted for by these built-in features, plus such design factors as greater load capacity and the elimination of loose or welded-in retaining rings. Multirol SE Series bearings, used with or without inner raceways in standard sizes of 5/8" to 9 1/4", are used extensively in machine tools, pumps, polishing machines, presses, power shovels, etc. — giving users a high degree of precision performance and longer bearing life.

Why not consult McGill engineers for helpful recommendations in applying these benefits to your product? Write McGill Mfg. Co., Inc., Bearing Division, 200 N. Campbell St., Valparaiso, Indiana. Ask for Bulletin SE-47.

McGILL®
precision bearings

performance.

In general, several available ceramic materials might serve advantageously for parts operating in the hot zones of gas turbines. Coatings for metals seem particularly attractive for immediate use, while ceramic bodies might afford more outstanding benefits. Design or operational adjustments often may be necessary to obtain maximum performance from ceramic bodies. To evaluate and use all types of ceramic materials, close co-operation is required between ceramists and gas-turbine engineers. With this co-operation, gas turbines with higher operating temperatures, longer life, or both, and, perhaps, lower weight seem within the realm of not-too-distant possibilities. *From a paper by W. H. Duckworth and I. E. Campbell, assistant supervisors, Battelle Memorial Institute, at the Dec.* 1949 *ASME Annual Meeting in New York.*

The Industrial Designer's Best Friend

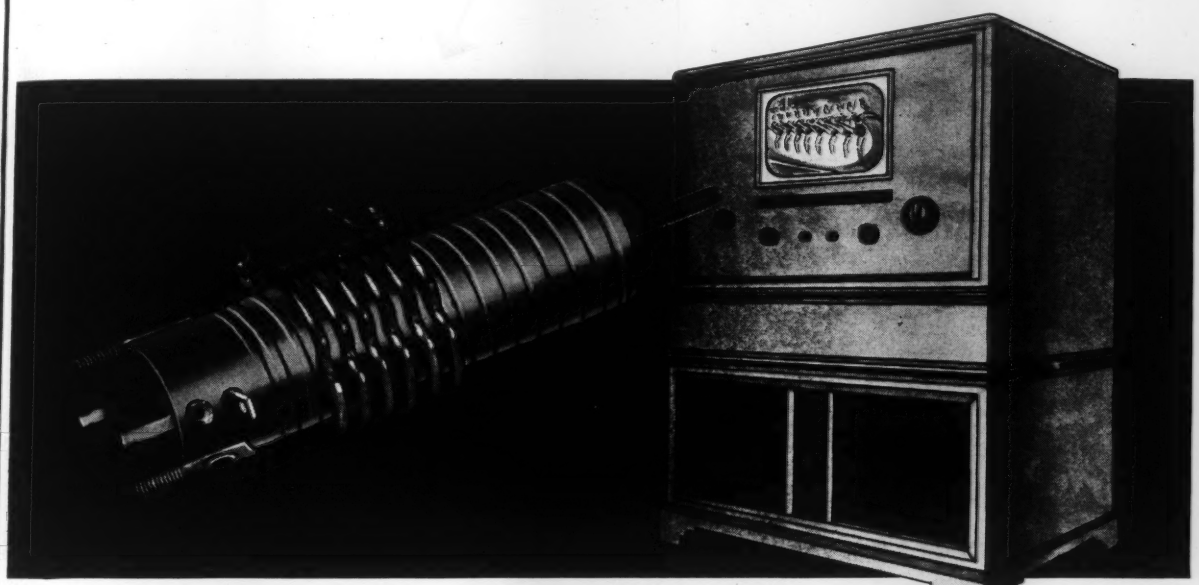
THE industrial designer made his formal debut about 20 years ago when most manufacturers—desperately striving to make their products stand out from competitive products—were decorating them within an inch of their lives. Sewing machines were covered with mother-of-pearl scrolls, lavatories had dainty wreaths of roses around their perimeters, cars, whose manufacturers had at last reluctantly discarded the useless whip socket, still persisted in using imitation caning as a decoration, and fountain pens were so covered with gold relief that writing became a major effort. The first industrial designers found a ready field.

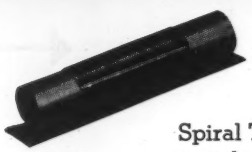
The vital factors the industrial designer must consider are: Convenience of use (including utility and safety); maintenance; costs (consideration of tooling, general manufacturing costs and distribution problem); sales (merchandising knowledge, public acceptance and awareness of competition); and appearance (the designer must add his knowledge of form line, proportion and color to integrate the product into a pleasing whole).

No industrial designer worthy of the name could contemplate this work without the close co-operation of engineers. If the designer is to be guided by the function of the product he is designing, he must rely on the client's design engineer to fully acquaint him, not only with mechanical problems involved, but also with the fabrication characteristics of the materials to be used. Likewise, the

another C-D development . . .

a strong, lightweight, LOW-COST tubing for your electrical applications





Spiral Tubing—one of the many developments that have helped bring television into the mass market. Recently introduced by Continental-Diamond laboratories, it is ideal for electrical, radio, and television applications where a good dielectric tubing with high strength and lightweight is needed. It is available in a variety of sizes and grades to meet requirements for low moisture absorption, forming, riveting, drilling, tapping, etc.

It is another example of why it pays to see C-D first in your search for the right plastic. C-D Plastics provide *practical* combinations of mechanical, electrical, and chemical properties—structural strength, lightweight, moisture, heat and corrosion resistance. For fast delivery, or help with material selection problems, call your nearest C-D office, any time.

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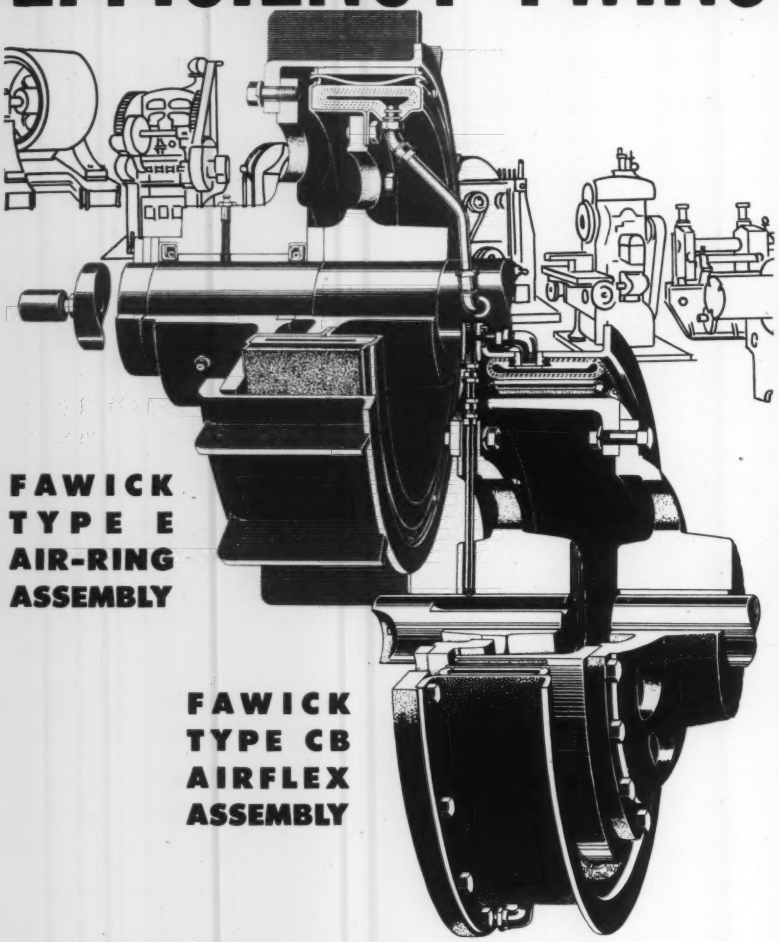

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Working individually or in combination, they provide Fawick-equipped machines with those operating characteristics which result in top machine performance. Quick response, positive action and control, elimination of lubrication, mechanical linkage and clutch adjustment comprise some of these advantages. The rugged design and construction provide long trouble-free machine operation in heavy-duty service.

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industrial designer must, as one of his first steps, acquaint himself with his client's factory. He must thoroughly understand its production facilities, and he must accept such limitations as exist not as restrictions but rather as a challenge.

Fortified with an understanding of strengths and weaknesses of his client's manufacturing capabilities, the industrial designer must next do research into the client's competitive field. In order to make full use of his knowledge of merchandising, he must find out not only what is selling best, but also, through research, and intelligent translating of it, what will sell best three or four years in the future. After all, that is when the product he is now working on will be marketed.

Co-operation in Design Phase

With these two fix points—knowledge of the factory and knowledge of the competitive market—established, the design is developed in closest co-operation with the engineering department of the client. At each step consultation is necessary to insure that the design is completely practical for manufacturing.

The engineer has assumed the role of the designer's best friend and severest critic and that, I think, is as it should be. There are many reasons for this. One is that the engineer has come to realize that the designer, with his outside point of view, can be of inestimable value in the creation of a new product. Another is that the engineer has found from experience that the industrial designer often can contribute ideas for arrangement of mechanical parts that will help the mechanical efficiency of the finished product, and at the same time assure the excellence of its exterior form and enhance sales value.

Still another reason lies in the fact that engineers are anxious to have their brain children look as well as they perform. And they have come to recognize that the industrial designer, with his outside point of view and his established reputation will be accepted by management as an authority on the very controversial subject of appearance—a subject on which everyone considers himself an expert! On his side, the industrial designer has been taught by experience that he must accept the engineer's superior knowledge of the practical aspects of a particular product. All the slick pictures that the designer can devise will mean nothing unless the engineer can translate them into a practical reality.

It is vital that members of the en-

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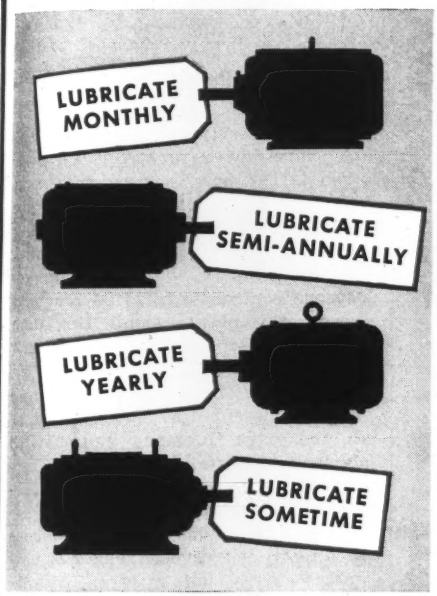

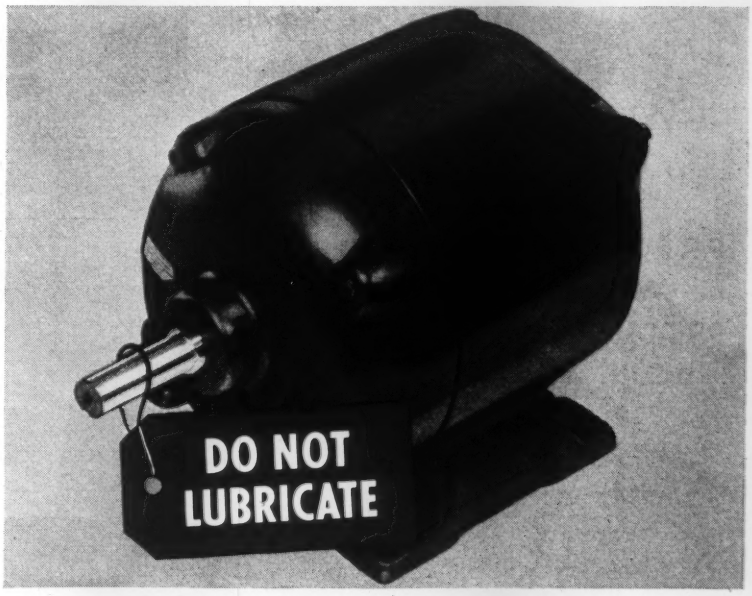

Why take a chance with "Once-in-a-while" lubrication?

Why fuss with motors that require lubrication "every so often?" Whether it's monthly, yearly, every two or three years, or just an indefinite "sometime," it is as much trouble remembering when to lubricate, as it is to do the lubricating. And it certainly isn't a very good way of making sure bearings get proper greasing attention.

There *is* one way to be *sure*. That's with Life-Line motors. Lubrication is *positive*. Bearings are pre-lubricated and factory-sealed. *No* further lubrication is required!

This is the modern way of lubricating motors. Development of special lubricants, up-to-date manufacturing methods and special seals have made it possible.

Records of nearly half a million motors, operating in every type of industry, indicate that pre-lubricated bearings offer: an average saving of $2.70 yearly per motor . . . 41% fewer motor outages due to faulty lubrication . . . complete freedom from lubrication attention.

Today, periodic lubrication is a costly nuisance. So why take a chance with it when Life-Line offers positive lubrication at no extra cost. See for yourself. Ask your Westinghouse representative for a copy of "Facts on Pre-Lubricated Bearings," B-4378, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

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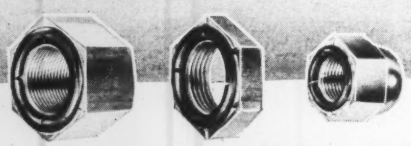

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gineering fraternity realize that the industrial designer is on their team; that he can supplement, but never supplant them. *From an address by Henry Dreyfuss presented Dec. 28, 1949 to the American Society of Engineering Educators at Stanford University, Calif.*

Printing Press Electronics

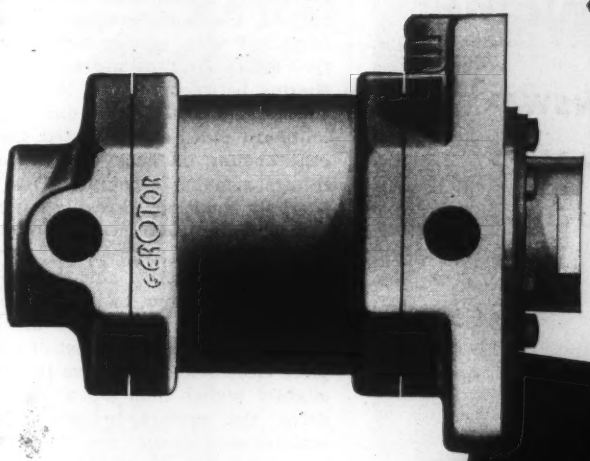
A VERY serviceable answer to the press drive problem has been given in the past, and is still being given in many plants, by the a-c double-motor drive. The operating speed range is provided by a wound-rotor main motor with secondary resistance control down to 20 per cent speed. A separate small threading motor is used for the jogging and low-speed threading functions.

This drive, however, suffers from certain inherent drawbacks. First of all, the extra threading motor, with necessary reduction gearing and overrunning clutch, causes undesirable mechanical complications. Second, efficiency of a wound-rotor motor drops off directly with speed. This not only wastes energy, but, in large installations, makes necessary expensive provisions for dissipating secondary resistor heat. Production speed, counting various slowdowns, seldom averages more than 70 per cent of full geared speed.

Third, speed regulation gets progressively worse as speed is reduced. To compensate for different loads, as press units are added or subtracted to vary the number of pages in the newspaper, special adjustments must be made to the secondary resistors. Unless these are properly made, a web break may result from excessive acceleration when going from threading speed to minimum operating speed.

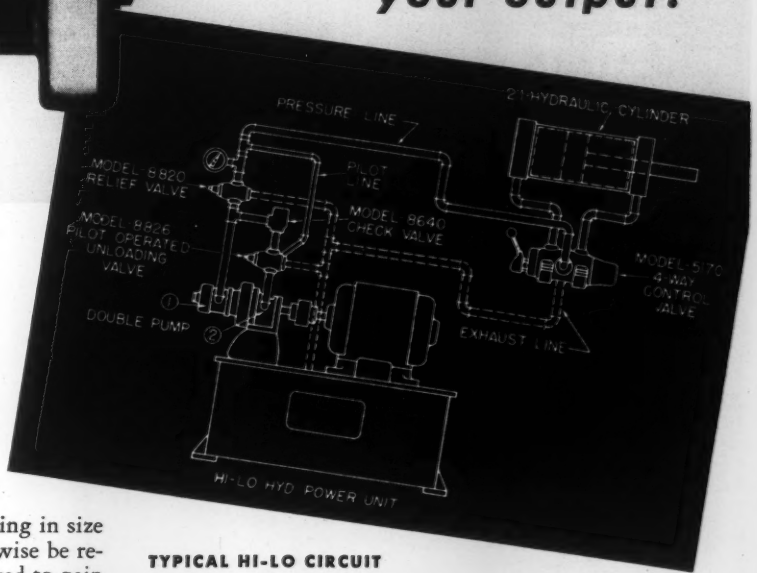
The electronic printing press drive eliminates these drawbacks. Jogging and threading, as well as high-speed operations, are accomplished by the main motors. These are mounted on the side frame of the press, co-axially with the press shaft, in the simplest possible mechanical arrangement. Overall efficiency of the system stays at a high value over the full production range. Speed and acceleration rate are not materially affected by load changes.

The adjustable voltage rectifier achieves all this by combining the advantages of a-c power distribution with the excellent speed control characteristics of d-c motors. At the same time, a high degree of reliability is maintained by use of dependable, time-proven components arranged in



Double the Rod Size—

and increase your output!



TYPICAL HI-LO CIRCUIT FOR HYDRAULIC PRESSES

This circuit illustrates a press application where rapid speed and low pressures are required for the major portion of the stroke and high pressures are required for the "squeeze" portion of the stroke. The output of both the low pressure high volume pump (2) and the high pressure small volume pump (1) is directed to the hydraulic cylinder at a low operating pressure. When sufficient work load builds up, pressure in the system increases and the model 8826 pilot operated unloading valve unloads the output of pump (2) while the output of pump (1) is still directed to the cylinder. Direction of piston travel is controlled by model 5170 4-Way control valve. The horsepower requirement for this type of circuit is much less than if a single pump of sufficient volume and pressure for the application were used.

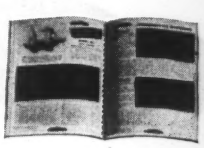
GEROTOR 1500 P.S.I. HYDRAULIC 2:1 CYLINDERS have a piston rod about twice as large as standard cylinder rod size. The larger rod reduces oil displacement, permitting it to retract at twice the speed that it extends. This speed-up shortens cycle time, allowing the rod to extend again quickly, thereby accomplishing more work!

This faster speed is gained with a saving in size of motor and pump which would otherwise be required. 2:1 cylinders may also be employed to gain identical retracting and extending speeds, as well as to support larger loads where straight linear motion is used.

Available in 6 standard mountings: Foot, Trunnion, Center Line, Blind End Flange, Rod End Flange, and Clevis; in 10 bore diameters; in any stroke up to 96″; and with cushioning.

Remember—Gerotor Hydraulic Cylinders have Keeper ring design, permitting the cylinder to be rotated to convenient pipe connection.

Send for Catalog Section No. 104 illustrating and describing all types and sizes of Gerotor Hydraulic Cylinders.



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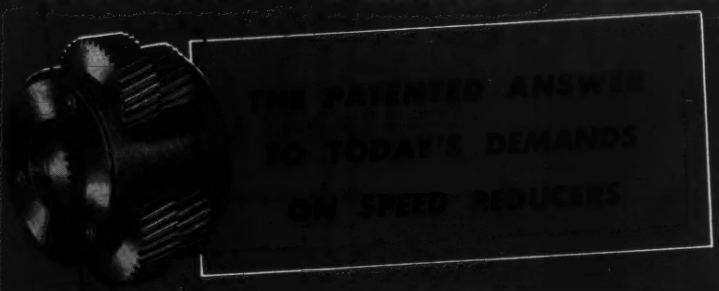

Load distribution that is not only equal to begin with but remains self-equalizing during years of wear! That's the promise, and the practice, of Winsmith's Patented Differential Speed Reducers.

For, Winsmith's unique Floating Pyramid, a 6-gear planetary element, is free within the reducer housing to assume the most effective load distributing position. Thus it portions the load equally over a large total area of helical teeth, assuring quiet, vibrationless operation. In terms of dollars and cents value in your plant, or as a component of equipment you make, Floating Pyramid gears slash reducer maintenance and replacement costs.

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Whether your required reduction is 2:1 or 50,000:1 in transmitting fractional H. P. or 80 H. P., overall dimensions of the compact Winsmith Differential you select from stock, remain the same . . . the number of parts remains the same.

To make your power transmission a still stronger link in your production chain, Winsmith transmission engineers will review your present or projected power systems . . . will help gear your plant to today's demands for higher performance at lower cost, ***without obligation.***

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a basically simple system.

As many as nine 40-hp motors are mechanically coupled to operate in parallel to drive large press combinations. Compound-wound motors are furnished with just enough cumulative series field to provide for load sharing between motors. A motor is furnished for each press unit, so, as units are added or subtracted, the per cent loading on each of the motors in use remains constant. Thus, essentially shunt speed regulation characteristics are obtained regardless of press size.

The operational advantages described can often be justified economically when all factors are considered. Although first cost of a complete electronic press drive is usually slightly higher than a-c wound-rotor drive, the savings in power costs, maintenance costs, and installation costs tends to more than make up the difference. These savings vary widely, so only the factors affecting them will be discussed.

Simplification Reduces Maintenance

Power savings result from the higher efficiency at reduced speeds of electronic drive over wound-rotor drive. Electronic drive lends itself particularly well to treatment in the same manner as modern switchgear. Installation costs are reduced to a minimum by virtue of factory assembled and wired cubicles which need only be bolted down and interconnected. Since no major power is dissipated in the control room, special ventilation is not required.

Electronic drive furnishes, with its direct coupled d-c motors, all the functions formerly requiring a main motor, a threading motor, reduction gearing, an over-running clutch, a mechanically operated brake, and a chain drive. Reduced maintenance expense can thus be expected.

Printing presses are a sound field for application of electronic motor drive. Functionally, this drive is superior to any conventional type. Reliability is equal or superior to that of any other drive. Economically, electronic drives can be justified in the majority of metropolitan installations and, as advances continue to be made, will certainly become more and more adaptable to smaller installations., All things considered electronic drives give definite promise of being the printing press drive of the future. *From a paper by J. A. Johnson, chief electrician, Times-Mirror Co., and E. M. Stacey, General Electric Co., at AIEE Winter General Meeting, Jan.* 30, 1950 *in New York.*

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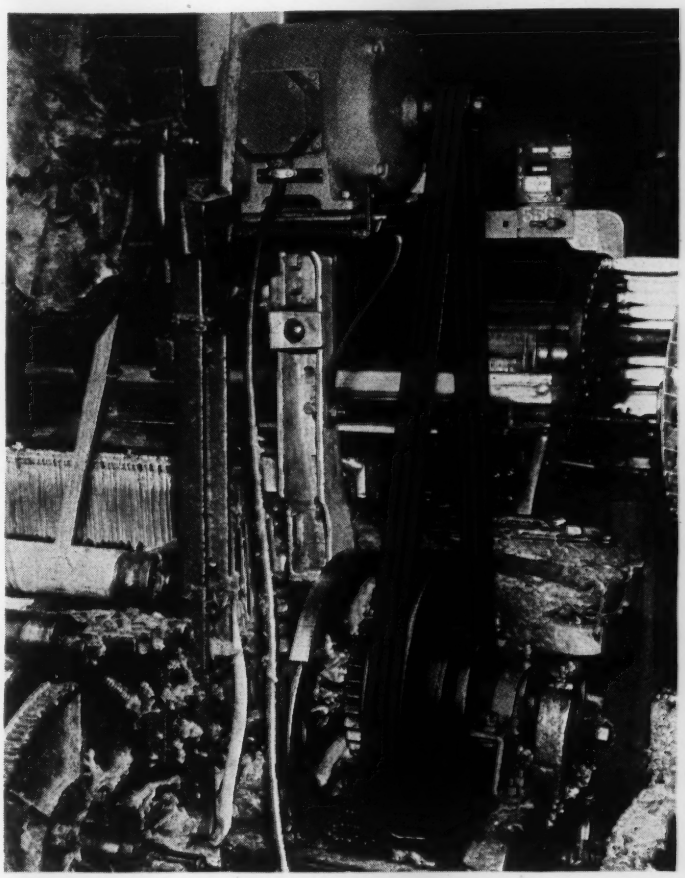
by Gates *SPECIALIZED* Research



THE extremely small diameter of pulleys over which loom drive V-Belts must flex under severe shock-loads posed a problem in V-Belt construction that seemed *insurmountable.*

But, with war-born synthetic fibers of unusual strength; and with man-made rubbers possessing engineering properties never available before—and with the great research and testing facilities available at Gates—a V-Belt was achieved that met the rigorous conditions of loom drive operation.

Then, a clutch of very advanced design was wanted—a clutch that would do *more,* with *less* maintenance, and *fewer* troublesome adjustments than the clutches commonly used with gear and pinion drives on looms.

Gates therefore engineered a clutch that is a marked improvement over the clutches previously available for looms.

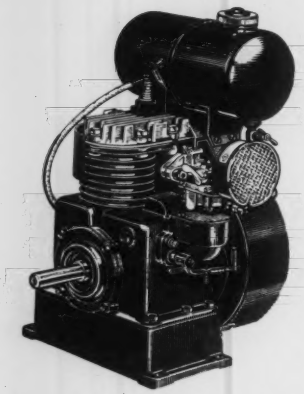
Finally—and this was most important, too—the entire drive assembly had to be so designed that it would go on the loom without any costly re-arrangement of existing mill equipment. This rather demanding job of design was also accomplished.

Today, the Gates V-Belt Drive for looms is cutting operating costs—and giving bigger loom output with better quality of cloth—in Cotton Mills and Rayon Mills the country over—another accomplishment of Gates *SPECIALIZED* Research!

ENG-505

THE GATES RUBBER COMPANY
The World's Largest Makers of V-Belts
DENVER, U.S.A.

GATES VULCO ROPE DRIVES
Engineering Offices and Jobber Stocks IN ALL INDUSTRIAL CENTERS of the U. S. and 71 Foreign Countries



Model K7-1, 1½ H.P. 4-cycle, single cylinder, air-cooled. Length 13", width 14", height 17", Weight 38 lbs.

POWER FOR:
Farm Equipment
Garden Tractors
Water Pumps
Concrete Mixers
Construction Equipment
Conveyors
Rollers
Compressors
Sprayers
Motor Bikes
Scooters
And other uses.

Four-Cycle, Air-Cooled KOHLER ENGINES

Compact • Quick-Starting Reliable

Kohler Engines are designed, engineered and built to give the same dependable, economical service that has won world-wide acceptance for Kohler Electric Plants in construction and other industries. Made in several sizes, they are suited to a wide range of uses. Kohler engineers will gladly assist in working out applications for your particular requirements. Write for information. Dept. 14-V, Kohler Co., Kohler, Wisconsin. Established 1873.

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Designed to do the Job

Wheels and Axles are our business, and our engineers are well qualified to recommend the most efficient assembly for your product.

Our factory is modern and tooled for low cost production. We have supplied manufacturers in many different industries for more than 50 years.

Standard or Special, ELECTRIC Spoke-type or Disc Wheels are built for most types of portable equipment.

Send us your specifications and we will submit our recommendations.

ELECTRIC WHEEL CO., 2915 Pine, Quincy, Ill.

NEW MACHINES

And the Companies Behind Them

Business Equipment

PORTABLE TYPEWRITER. Standard, full-size, low-cost model. Features segment shift, eliminating bobbing carriage. Has "office typewriter" arrangement of letter keys and spacing of keys and rows. Finished in brown. Royal Typewriter Co. Inc., New York, N. Y.

MANUAL TYPEWRITER. Redesigned for reduced maintenance costs. Side plates remove, hinged carriage assembly folds back to facilitate inspection and cleaning. New paper insertion scale makes center typing easier, sets margins and simplifies centering of letterheads. Remington Rand Inc., New York, N. Y.

Commercial Equipment

PAY METER. For installment buying of appliances in customer's home. Unit plugs into wall electrical outlet, appliance plugs into meter. Low-cost meters available in models requiring 25 cents per day, hour or half hour. A.B.T. Manufacturing Corp., Chicago, Ill.

Domestic

AUTOMATIC CLOTHES WASHER. Features larger top opening than former model. Aluminum alloy agitator keeps clothes from tangling. Single dial control permits amount of water, temperature, and length of washing time to be varied. Any part of cycle can be lengthened or shortened at any time. Rinsing includes warm spray, cold spray and deep overflow rinse. Signal lights show when machine is in operation. Hot Point Inc., Chicago, Ill.

VACUUM CLEANER. Tank type model incorporates greater suction and self-locking attachments. Has improved demothing system, larger disposable dirt bags and portable container for cleaner's 11 attachments. Motor suspended in rubber for quietness, turned off and on by foot button. Weight, 16¾ lb; length, 25 in.; width, 7 in. General Electric Co., Bridgeport, Conn.

CLOTHES DRYER. Gas or electric powered. Dial can be set for desired degree of dryness. Machine entirely automatic, requires only setting of dial and pushing of start button. Clothes tumbled, then cooled after

"We designed with LPC Hydraulic Power—its simplicity eliminates dozens of gears, shafts and bearings, provides safety against breakage when overloaded—it gives smooth, quiet operation with maximum power and flexibility—permits finger-tip control of the work."
MANDT MFG. CO.
Columbus, Ohio

9 LaPLANT-CHOATE HYDRAULIC COMPONENTS on the Mandt "Swing" Loader!

ALL loading operations are hydraulic on the Mandt "Swing" Loader — designed with nine LaPlant-Choate Hydraulic Components for the easier, faster, safer operation that means more efficient performance. Mandt selected LaPlant-Choate hydraulic design for the extreme simplicity of fluid power control, the smooth and quiet operation with instant response to controls, and construction that insures long life with maximum of power, speed and flexibility.

DESIGN *YOUR* PRODUCT WITH FULL HYDRAULIC OPERATION

LIKE the Mandt Mfg. Co., you can design *your* product with all the advantages of LPC Hydraulic Units. Be sure you get the most efficient and versatile unit available — LaPlant-Choate Hydraulic Units have been standard equipment on LPC earthmoving equipment for over 25 years.

The Famous Single-Unit LPC Fluid Power Control

Pump, valve and oil reservoir are all combined into a single compact unit. This new "closed system" design completely eliminates long suction lines, reduces the hazard of leaks and assures greatly increased speed and efficiency. In addition, the entire unit is skillfully engineered and precision built for utmost simplicity, easy servicing, and long, trouble-free operation.

Ask for Bulletin B-1152C LaPlant-Choate Manufacturing Co., Inc., Cedar Rapids, Iowa.

LaPLANT CHOATE

Weldments by Littleford

EXPERIENCE IS YOUR ASSURANCE OF QUALITY WORK AT A LOW COST

Design Engineers have found Littlefords' experience in shearing, flame cutting, punching, bending, rolling and welding plate and sheet metals a great boon in developing new products. Fabricated Weldments by Littleford have found a place in almost every industry. Engineers know too that Littleford fabricates with unerring precision and assumes a definite responsibility for the quality of the finished product. If you have a Weldment problem and want this Littleford experience and "know how" to work for you, send blueprints for an estimate of cost or write for the Bulletin on Littleford Weldments.

FABRICATORS OF PLATE AND SHEET METALS

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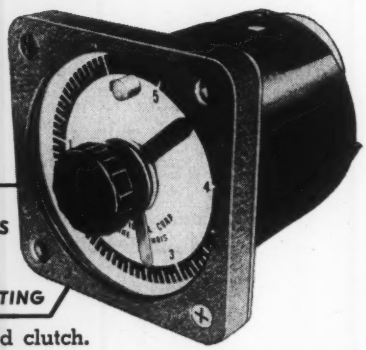
LITTLEFORD BROS., INC.
424 E. Pearl Street, Cincinnati 2, Ohio

New!

Small, Dependable INDUSTRIAL TIMER

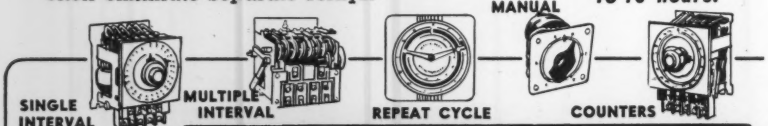
EAGLE Cycl-Flex



ELAPSED TIME INDICATOR
SEALED WINDOW PROTECTS DIAL AND POINTERS
ENCLOSED MECHANISM
FLANGE FOR PANEL MOUNTING

- Positive action insured by toothed clutch.
- Accurate Timing provided by Synchronous motor.
- Auxiliary contacts on clutch solenoid often eliminate separate relays.

Dials available from 30 seconds to 10 hours.



AN EAGLE TIMER FOR EVERY TIMING PROBLEM!

EAGLE SIGNAL CORPORATION Moline Illinois

heater shuts off. Capacity, 9 lb dry clothes or 20 lb wet clothes. Dimensions; 30 in. wide, 24¾ in. deep, 36 in. high. Weight, 192 lb. Horton Manufacturing Co., Fort Wayne, Ind.

Heating and Ventilating

WATER COOLING TOWERS. New line includes sizes from 3 to 50 tons capacity. Packaged units have interiors lined with rubber, deep-pitch, slow-speed fan for quiet operation. Aquatowers include open distribution basin, redwood filling, totally-enclosed motors and complete basin fixtures. The Marley Co. Inc., Kansas City, Kans.

UNIT HEATERS. Self-contained, gas fired models in seven capacities from 70,000 to 230,000 Btu/hr input. Aluminized steel combustion chamber and heat exchanger. All models finished in baked-enamel, bonderized steel casing. Burners adaptable for use with manufactured, mixed, natural or liquefied petroleum gases. American Blower Corp., Detroit, Mich.

AIR CONDITIONERS. For refrigerated storage in dairy, ice cream, meat packing, brewery, and other processing plants. Six models available in sizes to 25,000 cfm per unit. Coils arranged for flooded operation with high or low-pressure float control or liquid refrigerant pump recirculation. Low-pressure receivers have external float control in all cases. Cooling coils are spiral fin pipe, continuous, hot-dip galvanized after fabrication. Fan section consists of multiple centrifugal fans mounted on common shaft V-belt driven by single motor. Dimensions of smallest and largest units: 81¾ by 50¾ by 31 in. and 101 by 185¾ by 39¾ in. York Corp., York, Pa.

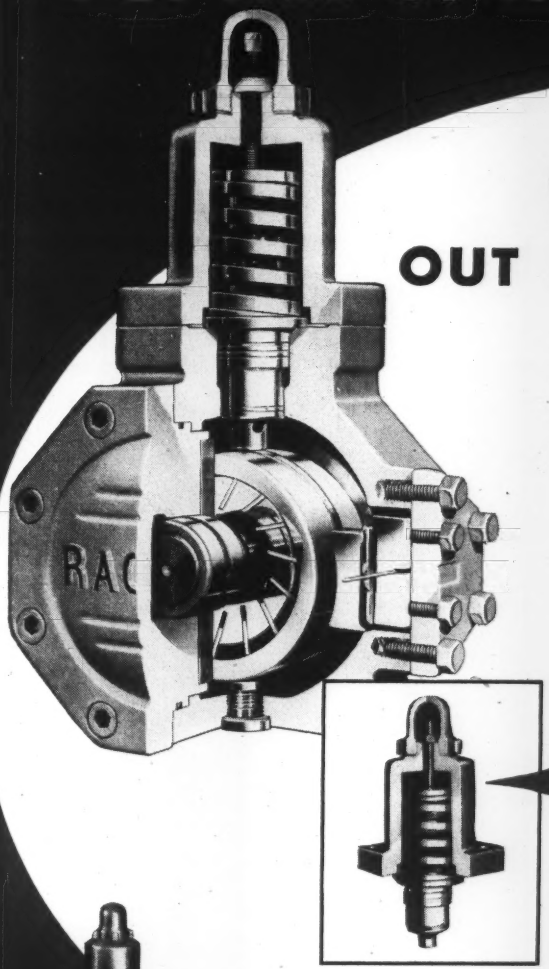
Manufacturing

TAPPING HEAD. For multiple tapping and drilling in mass production lines. Features silent roller chain drive to transmit power from Torquematic unit to individual spindles. Number of spindles limited only by size of drill or tap and by type of work. Charles L. Jarvis Co., Middletown, Conn.

PORTABLE DRILL. Capacity, ¼-in.; length, 7½ in.; weight, 3¾ lb. Features Lamb handle grip shaped to fit operator's hand, resulting in reduced fatigue. Standard no-load speed, 1800 rpm; also available in 6 other speeds ranging from 550 to 5000 rpm. Skilsaw Inc., Chicago, Ill.

PRESS. Air-operated, oil hydraulic press equipped with 8-station air-

Put ALL of the Oil to Work



Get the Most

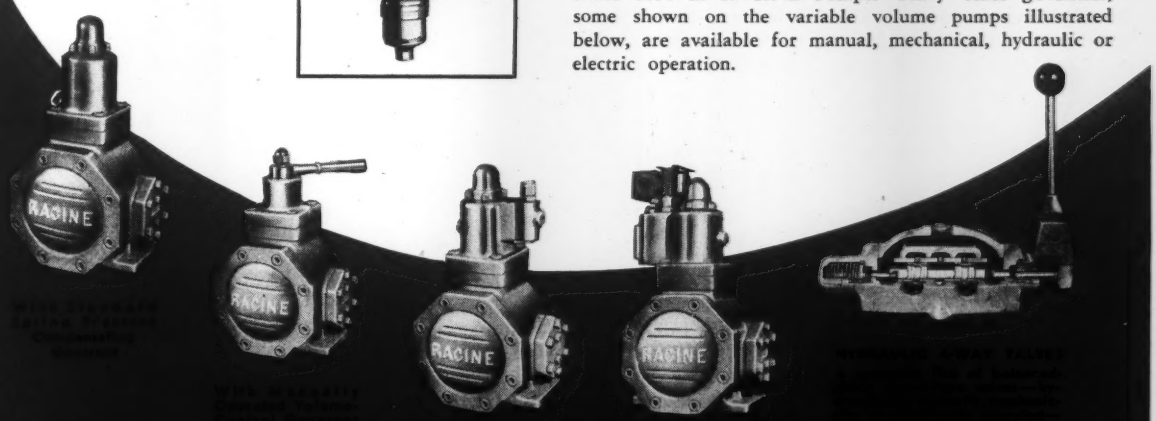
OUT OF YOUR CIRCUITS

Top circuit efficiency demands effective regulation of volume and pressure. RACINE Pumps are all equipped with built-in governors — an exclusive RACINE feature. These governors regulate pressure and control the oil flow, delivering *only* the volume needed for the work of the circuit. They "put all of the oil to work." No by-passing — no relief valves — heating is reduced — horsepower conserved.

Governor-controlled RACINE Pumps give you efficiency, flexibility, and economy over a wide range of circuit conditions. Why not review the advantages "Variable Volume" offers for machines in your plant and for your product.

Interchangeable Governor Controls

At left is illustrated a standard pressure-compensating governor used in RACINE Pumps. Many other governors, some shown on the variable volume pumps illustrated below, are available for manual, mechanical, hydraulic or electric operation.



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actuated automatic dial index table. Automatic cycling accomplished by energizing reset timer which starts down stroke. After preset time, timer de-energizes solenoid valve to start ram upstroke. At top of stroke, switch advances table to next position. Cycle time adjustable between 1 and 60 sec. Parts can be ejected mechanically or with exhaust air. Press capacities, 2½ and 5 ton; strokes, 2 or 5 in. Pressure, stroke and speed of ram adjustable. Hy-Air Products Co., Jackson, Mich.

DRILLING AND REAMING MACHINE. Roto-Matic station type vertical indexing machine for drilling and reaming 2 suspension holes and one kingpin hole in automotive front suspension support arms. Consists of 5 work stations and 1 loading station, with automatic cycling of machine proper and power heads. Davis & Thompson Co., Milwaukee, Wis.

DROP STAMP. Air-operated unit uses impact blows of controlled intensity. Redesigned stamps have 10 per cent increased capacity over previous models. Control mechanisms located where operator cannot be injured by moving parts. Safety rests in side frames hold ram up when changing dies or working between dies. Yoke-to-frame joints cushioned for shock insulation. Chambersburgh Engineering Co., Chambersburgh, Pa.

LATHE. Has 1-in. collet capacity, 11-in. swing, 1⅜-in. spindle bore, and center distances of 24 or 36 in. Includes spindle speed range of 45 to 1500 rpm. Bed ways ground to 0.0005-in; spindle has less than 0.0005-in. total run-out 12 in. from front bearing. Lathe is pedestal-mounted with underneath drive enclosed. All controls at operators finger tips. Logan Engineering Co., Chicago, Ill.

LATHE. Quick change gear 10-in. lathes in 3, 3½, 4 and 4½-ft bed lengths. Three V-ways and one flat way hand scraped. Spindle bore, $\frac{27}{32}$-in.; max collet capacity, ⅝-in. Machine provides 48 thread cutting feeds, power longitudinal feeds or power cross feeds. Journal bearings finished to 5 microseconds. Available with flat belt drive to headstock giving 12 speeds from 48 to 1435 rpm, or with V-belt drive giving 16 speeds from 52 to 1365 rpm. South Bend Lathe Works, South Bend, Ind.

TUBE SEALER. Four-head geneva gear drive machine for sealing video electron guns to bulbs. Will handle ninety 24-in. diameter tubes per hour. Powered by ¼ and ½-hp motors at 1720 rpm with variable

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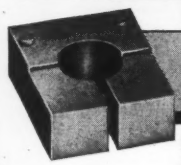
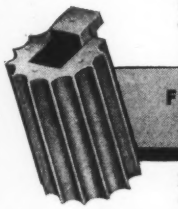
WEL-MET *makes them better*
. . . at less cost . . .
by POWDER METALLURGY



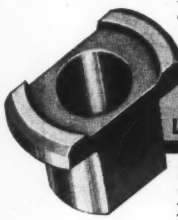
CUTTER CLAMP for Garden Tractor

Molded complete to print, without machining, at a cost saving of over 60%.



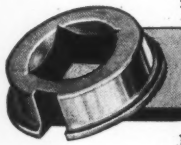
FEED ROLL FOR FARM SEEDER

Molded complete, including lug at one end, for 50% less than cost of machining.



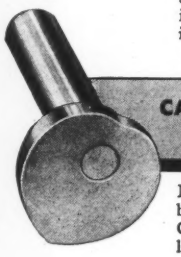
SPRING RETAINER for Lubrication Machinery

Formerly machined with high scrap loss. Now made economically from powdered metal.



RATCHET FOR DOOR CLOSER

Made to close tolerances from sintered iron powder. No machining. Self-lubricated.



CAM FOR TEXTILE MACHINERY

Iron powder cam brazed to steel shaft. Close tolerances. Self-lubricated.

Send blue prints, specifications and production requirements to . . .

The **WEL-MET** *Company*
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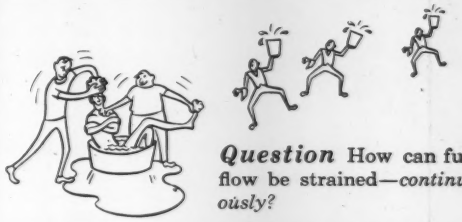
KENT, OHIO

There's just 1 answer

to all these questions about designing for clean fluid



Question How can full flow be strained—*continuously?*

Answer Cuno AUTO-KLEAN cleans full flow continuously because it can be cleaned, itself—periodically by hand or continuously by automatic means—*without stopping flow.*

Question How can I accommodate a straining device in *small* space?

Answer Cuno AUTO-KLEAN takes up minimum space per gallon—single unit occupies no more space than usual partial-flow type.

Question How can I adapt one design of strainer to *any* installation?

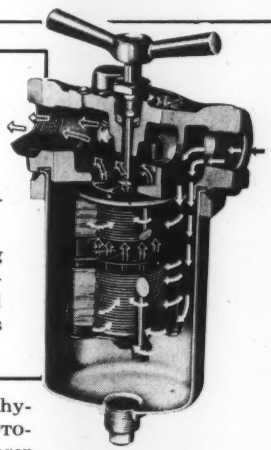
Answer Cuno AUTO-KLEAN can be supplied for built-in or external mounting . . . in any position of inlet and outlet . . . a few or more than 4000 gpm.

Question How can pressure drop be kept *low?*

Answer Cuno AUTO-KLEAN causes minimum pressure drop—can be installed on low pressure or gravity feed or suction with no loss of efficiency.

Question How can I relieve user of *replacement* costs?

Answer Cuno AUTO-KLEAN will last as long as the equipment on which it is installed because it is all-metal and non-collapsible and can be made of proper materials for various fluids, viscosities, temperatures and solids.



For general services, particularly lube and hydraulic systems, specify compact Cuno AUTO-KLEAN, guaranteed to remove all particles larger than specified.*

No Fluid Is Better Than Its Filtration

CUNO

Complete Line

Fluid Conditioning

Removes More Sizes of Solids from More Types of Fluids

MICRONIC (Micro-Klean) • DISC-TYPE (Auto-Klean)
WIRE-WOUND (Flo-Klean)

**Models available for straining from .0035 to .062 in.*

Find Out How AUTO-KLEAN Can Solve Your Fluid-Cleaning Problems

- ☐ Air Actuated Instruments
- ☐ Air Tools
- ☐ Bakery Machinery
- ☐ Balers
- ☐ Blowers
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- ☐ Diesel Engines
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- ☐ Engines
- ☐ Gear Hobbing Machines
- ☐ Grinders
- ☐ Hobbing Machines
- ☐ Honing Machines
- ☐ Hydraulic Systems
- ☐ Incubators
- ☐ Instruments
- ☐ Lathes
- ☐ Lubricating Systems
- ☐ Machine Tools
- ☐ Meters
- ☐ Milling Machines
- ☐ Oil Burners
- ☐ Oil Well Drilling Equipment
- ☐ Paint Spray Systems
- ☐ Paper Machinery
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- ☐ Presses
- ☐ Printing Presses
- ☐ Pumps
- ☐ Radial Drills
- ☐ Rolling Mills
- ☐ Scrap Balers
- ☐ Spray Systems
- ☐ Superchargers
- ☐ Tapping Machines
- ☐ Test Stands
- ☐ Turbines
- ☐ Turret Lathes
- ☐ Welding Machines

OTHERS_____

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CUNO ENGINEERING CORPORATION
201 South Vine Street, Meriden, Conn.

Please send me a free copy of your AUTO-KLEAN bulletin. I am especially interested in the services checked.

Name.....Title.....

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City.....State.....

PLEASE ATTACH COUPON TO YOUR BUSINESS LETTERHEAD

Elliott

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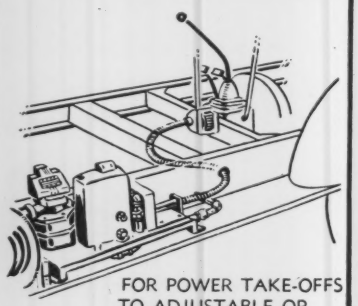
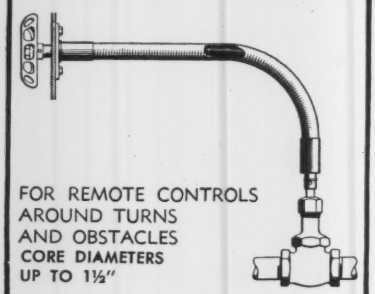


FOR POWER TAKE-OFFS TO ADJUSTABLE OR OUT-OF-LINE PARTS
CORE DIAMETERS UP TO 1-3/16"



FOR REMOTE CONTROLS AROUND TURNS AND OBSTACLES
CORE DIAMETERS UP TO 1½"

Elliott ENGINEERING AND DESIGN SERVICE

Backed by 50 years of experience in the Flexible Shaft and related fields, the Elliott engineering staff is constantly incorporating new and modern improvements in the design of their own equipment. This staff is available to you, as a part of the Elliott Service, to cooperate in working out the details of your own problems. We will be pleased to supply Flexible Shaft Data Sheets on request. These will aid you in furnishing us with certain necessary specifications such as r.p.m., torque, deflection, etc.

Write for Data Sheets and for Catalog 49 on your Company Letterhead

ELLIOTT
MANUFACTURING COMPANY
217 PROSPECT AVE. BINGHAMTON, N. Y.

speed pulleys. Machine automatically operated by reset timer which stops turret from rotating until previous operation is completed. Indexing time manually controlled by foot switch. Eisler Engineering Co. Inc., Newark, N. J.

BAND SAW. Metal cut-off saw handles 6-in. round and 6 by 12-in. rectangular stock. Driven by ½-hp motor through roller bearing equipped transmission. Uses ⅝ by 0.032-in. blade at speeds of 50, 100, 175 and 300 fpm. Machine has attached cooling system. Famco Machine Co., Racine, Wis.

WET GRINDER. Vertical spindle grinder for gear casings, ball housings and other large castings from 3 to 7 in. thick. Rotary work table drives 4 vertical shafts carrying work holding fixtures. Pressure plates hold work against 72-in. abrasive wheel. Grinder will handle 18-in. diameter by 6¼-in. thick gear cases to flatness tolerance of 0.005-in., removing $\frac{1}{32}$-in. stock at rate of 329 castings per hour. Charles H. Besly and Co., Beloit, Wis.

SHEET ROLLER. Forms standing "S" cleat in one pass through machine. Handles 20 to 26 gage at speed of 55 to 60 fpm. Pocket depth, $1\frac{1}{16}$-in.; height of angle, 1-in. Powered by 5-hp 220 or 440-volt motor. Special roll sets can be made for other rolling operation. The Lockformer Co., Chicago, Ill.

DRAWN SHELL TRIMMER. For flat edge trimming of drawn stampings. Handles any depth 16 gage material, with minimum radii on irregular shells of ⅛-in. External rotary cutter blade requires profile mandrel about ½-in. thick to fit drawn finished shell. Capacity, 65 shells per minute. Dayton Rogers Manufacturing Co., Minneapolis, Minn.

Materials Handling

BELT CONVEYOR. Two-wheel power booster and stacker weighs 350 lb, can be easily rolled into position on cushion rubber or pneumatic tires. In 10 and 16-in. belt widths, 5 standard lengths from 11 to 21 ft. Box channel slider bed formed of ⅛-in. heat-treated aluminum alloy with steel trussing on larger models for added rigidity. Operates horizontally or at any angle to 40 degrees. Two-way belt travel permits use for loading or unloading. The Rapids-Standard Co. Inc., Grand Rapids, Mich.

CONVEYOR TURNS. Power conveyors use tapered steel belt sections to obtain 90 and 180 degree turns. Belt has flat surface through turn, with inside radius of 36 in. Driven

SPRING IS SURE HERE!
IN GARRETT SPRING WASHERS

CONTROLLED TENSION

Garrett Spring Washers are made to hold right . . . stay tight. Exclusive Controlled Tension built into each washer to provide exact holding power for longer time.

PRECISION SIZES

Each washer is made to meet exacting size specifications—I. D., O. D., height and material thickness is scientifically controlled to Nth degree accuracy.

RIGIDLY INSPECTED

Garrett's laboratories and quality control tests assure highest quality in finished products. Size, shape, and finish are all carefully checked to meet rigid specifications.

100 VARIETIES

Bellville, bevel, wave and many other types are all included in the more than 100 varieties of types and sizes available in Garrett's standard line. We welcome your request. Send in your specifications. We can probably save you plenty in die costs. Write for our booklet. Let us prove it.

GARRETT'S MANUFACTURE A COMPLETE LINE OF LOCK WASHERS . . . FLAT WASHERS . . . STAMPINGS . . . HOSE CLAMPS . . . SPRINGS

GEORGE K. GARRETT CO., Inc.
PHILADELPHIA 34, PA.

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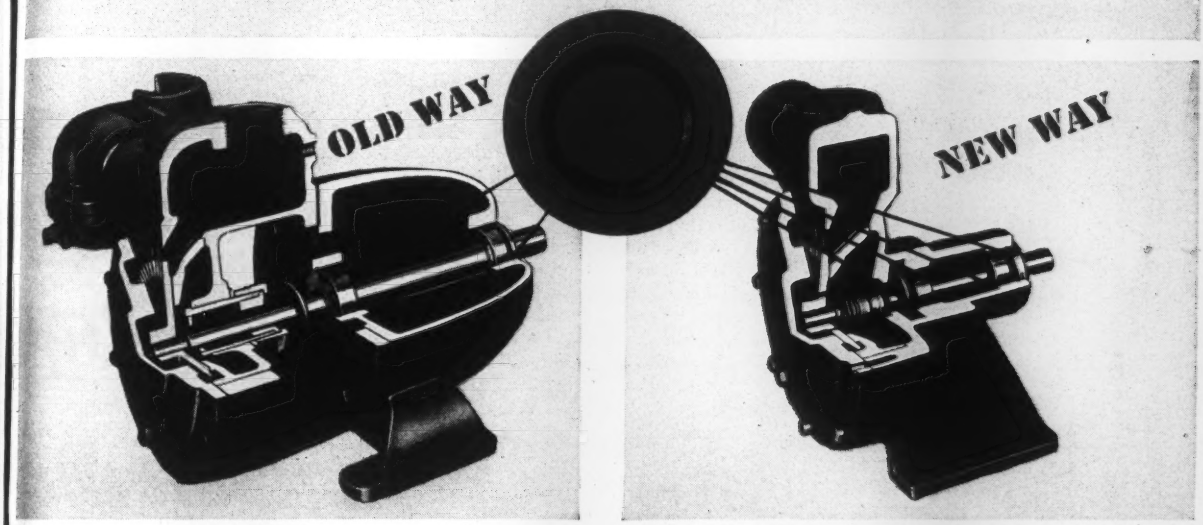
OF PHILADELPHIA

REDESIGN TRIMS LENGTH 5¼ INCHES, CUTS UNIT COST $5.70



Series D Wayne water pump uses machined shoulders to position bearings on shaft. 2 Truarc rings hold bearings in housing. Locknut holds screw-type stuffing box that requires periodic tightening.

New design uses 4 Truarc Inverted rings (2 external, 2 internal) to position shaft, retain bearings. Inverted rings provide shoulders of uniform section height. 1 Standard ring secures maintenance-free mechanical seal.

Redesign with Truarc Rings helps save $5.70 per unit for Wayne Home Equipment Company, Inc., Fort Wayne, Ind. It gives them a more compact product, eliminates a separate bearing pedestal and a skilled-labor grinding operation. It facilitates use of maintenance-free mechanical seal instead of old type stuffing box.

Redesign with Truarc Rings and you too will cut costs. Wherever you use machined shoulders, nuts, bolts, snap rings, cotter pins, there's a Truarc Ring that does a better job of holding parts together.

Truarc Rings are precision engineered. Quick and easy to assemble, disassemble. Always circular to give a never-failing grip. They can be used over and over again.

Find out what Truarc Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

See the Truarc Exhibit, Booth #1135, at the A.S.T.E. Show.

REDESIGN WITH 5 TRUARC RINGS GIVES THESE BIG SAVINGS

- *Cuts length 5¼ inches*
- *Cuts total labor 15.3%*
- *Eliminates skilled-labor grinding operation*
- *Saves 38.3% materials*
- *Allows use of stock-size shaft, smaller bearings*
- *Eliminates separate bearing pedestal*

TOTAL UNIT SAVING . . . $5.70

WALDES TRUARC

REG. U. S. PAT OFF

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY U. S. PATS. 2,302,948; 2,026,454; 2,418,852 AND OTHER PATS. PEND.

Waldes Kohinoor, Inc., 47-16 Austel Place MD 052
Long Island City 1, N. Y.

Please send 28-page Data Book on Waldes Truarc Retaining Rings.

Name_____

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Company_____

Business Address_____

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